Ontario
Ministry of
Transportation and
Communications

MI-97

RELATIVE DENSITY, MARSHALL STABILITY AND FLOW - A COMPARISON OF CORRELATION DATA

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

RELATIVE DENSITY, MARSHALL STABILITY AND FLOW

A COMPARISON OF CORRELATION DATA

By

J.H. Dickson, Ph.D.

And

D. F. Lynch

MINISTRY OF TRANSPORATION AND COMMUNICATONS

Engineering Materials Office

Bituminous Section

May 1986

Contents

Page

Introduction 1

Background 1

Procedure 2

Discussion 4

I - All vs MTC Regional Laboratories (MTC (R))

A - Bulk Relative Density 4
B - Maximum Relative Density 7
C - Maximum Relative Density (Surface Dry) 8
D - Marshall Stability 8
E - Marshall Flow 9

II - Comparison of MTC (A) and MTC (M) Laboratories 9

III - Comparison of ALL, MTC (A), MTC (R) and MTC (M) Differences in the Means 10

Conclusions 11

Tables I to XVII

Figures 1 to 28

Appendix I

RELATIVE DENSITY, MARSHALL STABILITY AND FLOW
A COMPARISON OF CORRELATION DATA

INTRODUCTION

MTC Laboratories participate in testing correlations sponsored by a number of different groups with interests in the various uses of bituminous products whether alone or in bituminous concrete mixes.

Recently attention was drawn to the fact that MTC results for Bulk Relative Density appeared to be constantly high when compared to results of other laboratories in three different correlations. As a result a review of available information for Bulk Relative Density, and subsequently for other relative density and Marshall Tests was made in an effort to fully assess MTC's position in this area of testing.

BACKGROUND

In the AASHTO Materials Reference Laboratories (AMRL), Canadian Asphalt Exchange (CAE) and Canadian Testing Association (Ontario Chapter) (CTA) correlations it is the custom to give the participating laboratory a rating ranging from ±5 (good) to 0 (rejected). In most cases MTC laboratories rate in the good class. Thus any rating below 4 attracts particular attention.

In 1985, MTC Downsview laboratory participated, for the first time, in an AMRL bituminous concrete mix design correlation. The low ratings obtained for bulk relative density (bulk specific gravity) of 1 and 2 initiated a brief review of bulk relative density (BRD) data recorded in the CAE and CTA correlations. As it will be seen later an apparent trend toward high BRD values led to the decision to review MTC's position on the basis of first principles, in this case, hand compacted specimens using the basic Marshall equipment.

This report includes the review of Downsview laboratory data for three correlations along with a more complete assessment of the position of all five MTC regional laboratories in the CTA correlation. Maximum Relative Density (MRD), Maximum Relative Density surface dry (MRD (SD)), Marshall Stability and Marshall Flow test data are also included in the latter.

At the time of writing of this report the "recalibration" of the Marshall compaction hammers had not been completed.

PROCEDURE

Standardized (normal) deviate can be used to compare the value obtained for a particular test by a particular laboratory to that of the mean obtained for all the laboratories included in a correlation. The standardized deviate is expressed mathematically as follows:

$$S.D. = (x - \bar{x})/s$$

where: S.D. = standardized deviate

x = value obtained by a single laboratory

$\bar{x}$ = arithmetic mean for all laboratories

s = standard deviation for all laboratories

In the current study standardized deviates have been calculated for each regional laboratory (MTC (R)) on the basis of mean values calculated a) for all laboratories (ALL) in each correlation and b) for the regional laboratories involved in these correlations.

Coding for the regional laboratories is as follows:

01 Thunder Bay
02 North Bay
04 Eastern
05 London
06 Downsview (Mix Design)

Subsequently, the study was extended to included MTC mobile and Downsview evaluation laboratories which are coded as follows:

03 Central Mobile #1
07 Downsview Evaluation
08 Central Mobile #2
10 Eastern Mobile
19 Northern Mobile #1
20 Northern Mobile #2
45 Central Mobile #3

Above listed laboratories are designated as MTC (M) laboratories.

DISCUSSION

I - ALL vs MTC Regional Laboratories

I - A - Bulk Relative Density

Although all regional and mobile laboratories participate in the CTA correlation only the Downsview laboratory participates in each of AMRL, CAE and CTA correlations. Initially the position of Downsview vis-a-vis the populations of the three evaluations was evaluated for the BRD case.

The data from the 1985 AMRL correlation for BRD are listed in TABLE I. Both hand and mechanically compacted data representing the CAE correlation for BRD are included in the same Table. Finally BRD data for the Downsview laboratory (No. 06) in the CTA correlation are shown in TABLE II A & B. When these data are plotted in Figure 1 it is readily seen that all are on the high side compared to the mean value (the zero line) for all the laboratories participating in these correlations.

Statistically, points for any given laboratory would be expected to demonstrate a random distribution above and below the mean. On the other hand, when all the points are located on one side of the mean the presence of a bias is suspected.

In view of the information obtained for the Downsview laboratory it was decided to review the position of all the MTC regional laboratories with reference to a) the mean obtained for ALL laboratories and b) the mean obtained for the five MTC (R) laboratories. This portion of the study is, of necessity, limited to the CTA correlation since it is the only one in which these laboratories participate. It is also worthly of note that all participants in the CTA correlation are instructed to use the MTC laboratory manual as the reference to be followed for particulars in the test methods incorporated in this correlation.

The first test to be reviewed was the hot mix BRD. Standardized deviates for each regional laboratory were calculated for both the "ALL" and the MTC (R) cases. These data are listed in TABLE II A & B and plotted in Figure 2 to 6 inclusively. It can be readily seen that all MTC laboratories show consistantly high BRD values when compared to the mean for the ALL case. However, when compared to the MTC (R) case mean there is a fairly typical distribution of points above and below the mean indicating good agreement between the results from the MTC laboratories.

Confidence range of the mean value is given by the equation:

$$u = \overline{x} \pm \frac{S}{\sqrt{n}} \cdot t(n-1)$$

where u = confidence range of the mean

$\bar{x}$ = arithmetic mean

s = standard deviation

n = number of laboratories

n-1 = degrees of freedom

t = difference between the mean of the sample and the true mean of the population

Values of t for small values of n are considerably larger than for larger values of n. Therefore, assuming similar values for x and s, the confidence range for a smaller number of laboratories would be expected to be larger than for a relatively large number of laboratories. In this study, except for the ALL laboratory cases for 1984, standard deviations (S) lie within the ASTM D-2726 multilaboratory 1S maximum of 0.0269 (TABLE III). Of these, the MTC (R) standard deviations are considerably lower than those of the whole group. Thus, in spite of a much smaller number of laboratories in the MTC (R) cases, the difference between the range limits are quite similar in numerical value to those of the ALL laboratory cases. This is another indicator of the good level of agreement between MTC (R) laboratories.

Information from CTA type A certified mix design laboratories only, for 1984 and 1985 (Appendix I TABLES I and II) produced arithmetic means which are only slightly lower (0.004) than these for the ALL cases. Consequently, selection of data on this basis does not affect the results of the BRD study.

Thus MTC (R) laboratories exhibit BRD values which, while displaying good inter-MTC group agreement, are constantly higher than those of the ALL laboratory cases. It remains to be proven, therefore, which mean is more correct. In the case of BRD determinations the point of reference is based on hand compacted briquettes carried out under strictly specified conditions and using specified equipment. This work is currently in progress and will be reported at a later date.

I - B - Maximum Relative Density

Once again the Downsview data obtained from the AMRL, CAE and CTA correlations recorded in TABLES IV, V A and V B are compared in Figure 7. Again there appears to be a trend for data points to be on the high side of the overall mean albeit not as high by comparison as was the BRD. Furthermore, the continuous upward trend apparent in Figure 1 does not exist in Figure 7. On the contrary, in the MRD case the trend at least with reference to the CTA correlation is downward. It should be noted in passing that there is no relationship between the test procedures since BRD is directly related to compactive effort while MRD testing is carried out on a loose mix.

Standardized deviate values for each of the regional laboratories calculated from CTA correlation data for both the ALL laboratory and the MTC (R) case means are listed in TABLES V A and B and plotted in Figures 8 to 12. In general, all the regional laboratories show somewhat higher

values than the ALL case mean with the Downsview laboratory showing the least average deviation. However, in the MTC (R) case the latter laboratory shows a trend toward lower values while the other four regional laboratories show the expected random distribution.

MRD means, standard deviations and 95% confidence range of the means are listed in TABLE VI. While the MTC (R) standard deviations are smaller the 95% confidence range is larger than the ALL cases which is expected due to the smaller value for n. In every case MTC (R) mean is somewhat higher than the ALL mean.

I - C - Maximum Relative Density (Surface Dry)

The same approach as for MRD was applied to MRD (SD) with data recorded in TABLES VII A and B and plotted in Figures 13 to 17. Here again the trend is to higher standardized deviate values compared to the ALL means. As before MTC (R) case data show a random distribution about the MTC (R) mean. The remainder of the statistical data (TABLE VIII) also follows a pattern resembling that of the MRD data.

I - D - Marshall Stability

The Downsview data for Marshall Stability in AMRL, CAE and CTA correlations are recorded in TABLES IX, X A and X B and plotted in Figure 18. The influence of the high BRD values is reflected in the high

Marshall Stability values. This influence is also apparent for the individual MTC (R) laboratories in Figures 19 to 23. The remainder of the statistical data conform to normal patterns in keeping with n values (TABLE XI).

I - E - Marshall Flow

Marshall Flow data for CTA correlations are listed in TABLES XII A and B and plotted in Figures 24 to 28. As it can be seen the flow data seem not to be influenced by BRD and Marshall Stability nor are there consistent trends in the small differences between ALL and MTC (R) data. Here the plotted data show the expected random type distribution above and below the mean values.

II - Comparison of MTC (R) vs MTC (M)

Data for mean and standard deviations were next recorded for the ALL MTC laboratory, MTC (A), and the MTC (M) laboratory cases. BRD, MRD, MRD (SD) and Marshall Stability data for these combinations of laboratories are shown in TABLES XIII to XVI. In general, the mean data for MTC (M) group of laboratories are somewhat lower than those of all the MTC laboratories (MTC (A)) but remain higher than the ALL laboratory case. In other words, the MTC (M) group data are always lower than the MTC (R) or regional laboratory group.

III - Comparison of ALL, MTC (A), MTC (R) and MTC (M) Differences in the Means

Differences in mean data between the ALL laboratory case and three cases for MTC laboratories are summarized in TABLES XVII and XVIII. Overall arithemtic average data for the four year period studied are also included in these tables.

Two observations are worthy of note. Firstly, in all cases reviewed, with the exception of four data points for Marshall Stability for MTC (M), the MTC data are higher than the means for ALL laboratories. Secondly, average data for MTC (M) are always lower than those of the regional MTC (R) group of laboratories.

When considering BRD's, the less solid floors of the mobile units are suggested as a possible reason for the difference between MTC (M) and MTC (R) data. This would be reflected in Marshall Stabilities as well. However, no reasons are given for this difference in MRD and MRD (SD) at this time.

CONCLUSIONS

1 - Downsview laboratory data for BRD, MRD and Marshall Stability are constantly higher than the ALL laboratory means in AMRL, CAE and CTA correlations for the years 1983 to 1986.

2 - MTC laboratory data for BRD, MRD, MRD (SD) and Marshall Stability are consistently higher than the ALL laboratory means in the CTA correlations for the years 1983 to 1986.

3 - MTC (R) regional laboratories show higher values for these tests than those of the MTC (M) mobile laboratories. Less rigid floors in the mobile laboratories could be a contributing cause of differences in BRD and Marshall Stability.

4 - Marshall Flow is not effected.

5 - While MTC regional laboratories show higher BRD results than all other groups agreement within the group is good and although only five laboratories are involved the 95% confidence range of the mean is equivalent to that of the ALL laboratory group representing up to thirty-nine laboratories.

6 - Data from CTA Type A certified laboratories only had little or no effect on results of the BRD study.

TABLE I

BITUMINOUS CONCRETE - AMRL AND CAE CORRELATIONS - BRD

Correlation Sample	AMRL #3	AMRL #4	CAE Hand	CAE Mechanical
ALL (1983)				
n	-	-	27	24
$\bar{x}$	-	-	2.384	2.361
s	-	-	0.013	0.026
Downsview				
x	-	-	2.393	2.380
S.D.*	-	-	0.69	0.73
ALL (1984)				
n	-	-	26	22
$\bar{x}$	-	-	2.425	2.413
s	-	-	0.023	0.026
Downsview				
x	-	-	2.436	2.443
S.D.*	-	-	0.48	1.15
ALL (1985)				
n	89	89	28	28
$\bar{x}$	2.286	2.275	2.311	2.304
s	0.019	0.020	0.018	0.020
Downsview				
x	2.338	2.324	2.337	2.246
S.D.*	2.74	2.45	1.44	2.10

*S.D. = Standardized Deviate

TABLE II A

CTA CORRELATION - HOT MIX - 1983/84

		BRD				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.*	Data	S.D.	S.D.
ALL (1983)						
n		34	-	34	-	-
$\bar{x}$		2.336	-	2.361	-	-
s		0.020	-	0.024	-	-
x	01	2.348	0.65	2.381	0.83	0.74
	02	2.345	0.50	2.377	0.66	0.58
	04	2.363	1.41	2.394	1.41	1.41
	05	2.351	0.80	2.388	1.31	1.06
	06	2.363	1.36	2.370	0.37	0.87
MTC (R) (1983)						
n		5	-	5	-	-
$\bar{x}$		2.354	-	2.382	-	-
s		0.008	-	0.009	-	-
x	01	2.348	-0.75	2.381	-0.11	-0.43
	02	2.345	-1.13	2.377	-0.56	-0.85
	04	2.363	1.13	2.394	1.33	1.23
	05	2.351	-0.38	2.388	0.67	0.15
	06	2.363	1.13	2.370	-1.33	-0.10
ALL (1984)						
n		34	-	34	-	-
$\bar{x}$		2.384	-	2.396	-	-
s		0.032	-	0.030	-	-
x	01	2.401	0.54	2.421	0.85	0.70
	02	2.417	1.02	2.431	1.20	1.11
	04	2.424	1.27	2.440	1.49	1.38
	05	2.412	0.90	2.439	1.47	1.19
	06	2.410	0.84	2.419	0.78	0.81
MTC (R) (1984)						
n		5	-	-	-	-
$\bar{x}$		2.413	-	2.430	-	-
s		0.009	-	0.010	-	-
x	01	2.401	-1.33	2.421	-0.90	-1.12
	02	2.417	0.44	2.431	0.10	0.27
	04	2.424	1.22	2.440	1.00	1.11
	05	2.412	-0.11	2.439	0.90	0.40
	06	2.410	-0.33	2.419	-1.11	-0.72

*Standardized Deviate

TABLE II B

CTA CORRELATION - HOT MIX - 1985/86

		BRD				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1985)						
n		38	-	39	-	-
$\bar{x}$		2.395	-	2.382	-	-
s		0.016	-	0.019	-	-
x	01	2.415	1.25	2.396	0.74	1.00
	02	2.405	0.63	2.394	0.63	0.63
	04	2.418	1.44	2.410	1.47	1.46
	05	2.408	0.81	2.401	1.00	0.91
	06	2.408	0.81	2.401	1.00	0.91
MTC (R) (1985)						
n		5	-	5	-	-
$\bar{x}$		2.411	-	2.400	-	-
s		0.005	-	0.006	-	-
x	01	2.415	0.80	2.396	-0.67	0.07
	02	2.405	-1.20	2.394	-1.00	-1.10
	04	2.418	1.40	2.410	1.67	1.54
	05	2.408	-0.60	2.401	0.17	0.22
	06	2.408	-0.60	2.401	0.17	0.22
ALL (1986)						
n		35	-	35	-	-
$\bar{x}$		2.384	-	2.412	-	-
s		0.022	-	0.027	-	-
x	01	2.424	1.79	2.456	1.64	1.72
	02	2.412	1.22	2.439	1.00	1.11
	04	2.408	1.10	2.448	1.35	1.23
	05	2.414	1.31	2.438	0.95	1.13
	06	2.418	1.52	2.451	1.45	1.49
MTC (R) (1986)						
n		5	-	5	-	-
$\bar{x}$		2.415	-	2.446	-	-
s		0.006	-	0.008	-	-
x	01	2.424	1.50	2.456	1.25	1.38
	02	2.412	-0.50	2.439	-0.88	-0.69
	04	2.408	-1.17	2.448	0.25	-0.64
	05	2.414	-0.17	2.438	-1.90	-0.59
	06	2.418	1.24	2.451	0.63	0.92

TABLE III

CTA CORRELATION - HOT MIX - BRD STATISTICS

	Material #1	Material #2
ALL (1983)		
n	34	34
$\bar{x}$	2.336	2.361
s	0.020	0.024
Int.*	2.329/2.343(0.014)**	2.353/2.369(0.016)
MTC (R) (1983)		
n	5	5
$\bar{x}$	2.354	2.382
s	0.008	0.009
Int.	2.344/2.363(0.019)	2.371/2.393(0.022)
ALL (1984)		
n	34	34
$\bar{x}$	2.384	2.396
s	0.032	0.030
Int.	2.373/2.395(0.022)	2.386/2.406(0.020)
MTC (R) (1984)		
n	5	5
$\bar{x}$	2.413	2.430
s	0.009	0.010
Int.	2.402/2.424(0.022)	2.418/2.442(0.024)
ALL (1985)		
n	38	39
$\bar{x}$	2.395	2.382
s	0.016	0.019
Int.	2.392/2.400(0.010)	2.376/2.388(0.012)
MTC (R) (1985)		
n	5	5
$\bar{x}$	2.411	2.400
s	0.005	0.006
Int.	2.405/2.417(0.012)	2.393/2.407(0.014)
ALL (1986)		
n	35	35
$\bar{x}$	2.384	2.412
s	0.022	0.027
Int.	2.376/2.392(0.016)	2.403/2.421(0.018)
MTC (R) (1986)		
n	5	5
$\bar{x}$	2.415	2.446
s	0.006	0.008
Int.	2.408/2.422(0.014)	2.436/2.456(0.020)

*Int. = 95% confidence range of the mean
**Number in parenthesis is the difference between the range limits

TABLE IV

BITUMINOUS CONCRETE - AMRL AND CAE CORRELATIONS - MRD

Correlation Sample	AMRL #3	AMRL #4	CAE Fresh	CAE Aged
ALL (1983)				
n	-	-	24	23
$\bar{x}$	-	-	2.470	2.466
s	-	-	0.009	0.009
Downsview				
x	-	-	2.478	2.465
S.D.*	-	-	0.89	-0.11
ALL (1984)				
n	-	-	24	24
$\bar{x}$	-	-	2.513	2.578
s	-	-	0.012	0.012
Downsview				
x	-	-	2.520	2.522
S.D.*	-	-	0.58	0.33
ALL (1985)				
n	91	91	27	26
$\bar{x}$	2.4198	2.4173	2.394	2.403
s	0.011	0.012	0.010	0.006
Downsview				
x	2.439	2.430	2.402	2.408
S.D.*	1.75	1.06	0.80	0.83

*S.D. = Standardized Deviate

TABLE V A

CTA CORRELATION - HOT MIX - 1983/84

		MRD				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1983)						
n		34	-	31	-	-
$\bar{x}$		2.485	-	2.485	-	-
s		0.010	-	0.010	-	-
x	01	2.497	1.20	2.496	1.09	1.15
	02	2.498	1.30	2.496	1.09	1.15
	04	2.501	1.60	2.495	1.00	1.30
	05	2.490	0.50	2.485	0.00	0.25
	06	2.501	1.60	2.488	0.30	1.45
MTC (R) (1983)						
n		5	-	5	-	-
$\bar{x}$		2.497	-	2.492	-	-
s		0.005	-	0.005	-	-
x	01	2.497	0.00	2.496	0.80	0.40
	02	2.498	0.20	2.496	0.80	0.50
	04	2.501	0.80	2.495	0.60	0.70
	05	2.490	-1.40	2.485	-1.40	-1.40
	06	2.501	0.80	2.488	-0.80	0.00
ALL (1984)						
n		34	-	34	-	-
$\bar{x}$		2.525	-	2.547	-	-
s		0.015	-	0.014	-	-
x	01	2.538	0.85	2.559	0.85	0.85
	02	2.528	0.23	2.560	0.92	0.58
	04	2.537	0.78	2.562	1.06	0.92
	05	2.539	0.91	2.558	0.79	0.85
	06	2.528	0.17	2.555	0.58	0.38
MTC (R) (1984)						
n		5	-	5	-	-
$\bar{x}$		2.534	-	2.559	-	-
s		0.006	-	0.003	-	-
x	01	2.538	0.67	2.559	0.00	0.34
	02	2.528	-1.00	2.560	0.33	-0.34
	04	2.537	0.50	2.562	1.00	0.75
	05	2.539	0.83	2.558	-0.33	0.25
	06	2.528	-1.00	2.555	-1.33	-1.17

TABLE VI

CTA CORRELATION - MRD - HOT MIX STATISTICS

	Material #1	Material #2
ALL (1983)		
n	34	31
$\bar{x}$	2.485	2.485
s	0.010	0.010
Int.*	2.482/2.488(0.006)**	2.482/2.488(0.016)
MTC (R) (1983)		
n	5	5
$\bar{x}$	2.497	2.492
s	0.005	0.005
Int.	2.490/2.504(0.014)	2.485/2.499(0.014)
ALL (1984)		
n	34	34
$\bar{x}$	2.525	2.547
s	0.015	0.014
Int.	2.520/2.530(0.010)	2.542/2.552(0.010)
MTC (R) (1984)		
n	5	5
$\bar{x}$	2.534	2.559
s	0.006	0.003
Int.	2.527/2.541(0.014)	2.555/2.563(0.008)
ALL (1985)		
n	37	37
$\bar{x}$	2.529	2.523
s	0.012	0.012
Int.	2.525/2.533(0.008)	2.519/2.527(0.008)
MTC (R) (1985)		
n	5	5
$\bar{x}$	2.542	2.535
s	0.003	0.004
Int.	2.588/2.546(0.008)	2.530/2.540(0.010)
ALL (1986)		
n	35	35
$\bar{x}$	2.541	2.548
s	0.013	0.013
Int.	2.537/2.545(0.008)	2.544/2.552(0.008)
MTC (R) (1986)		
n	5	5
$\bar{x}$	2.553	2.556
s	0.006	0.008
Int.	2.546/2.560(0.014)	2.546/2.566(0.012)

*Int. = 95% confidence range of the mean
**Number in parenthesis is the difference between the range limits

TABLE V B

CTA CORRELATION - HOT MIX - 1985/86

		MRD				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1985)						
n		37	-	37	-	-
$\bar{x}$		2.529	-	2.523	-	-
s		0.012	-	0.012	-	-
x	01	2.545	1.38	2.539	1.38	1.38
	02	2.544	1.30	2.530	0.63	0.97
	04	2.542	1.17	2.533	0.92	1.05
	05	2.542	1.08	2.539	1.38	1.23
	06	2.538	0.78	2.533	0.88	0.83
MTC (R) (1985)						
n		5	-	5	-	-
$\bar{x}$		2.542	-	2.535	-	-
s		0.003	-	0.004	-	-
x	01	2.545	1.00	2.539	1.00	1.00
	02	2.544	0.67	2.530	-1.25	-0.29
	04	2.542	0.00	2.533	-0.50	-0.25
	05	2.542	0.00	2.539	1.00	0.50
	06	2.538	-1.33	2.533	-0.50	-0.92
ALL (1986)						
n		35	-	35	-	-
$\bar{x}$		2.541	-	2.548	-	-
s		0.013	-	0.013	-	-
x	01	2.552	0.85	2.550	0.10	0.48
	02	2.554	1.04	2.561	0.95	1.00
	04	2.557	1.18	2.554	0.40	0.79
	05	2.560	1.45	2.566	1.33	1.39
	06	2.543	0.17	2.547	-0.08	0.05
MTC (R) (1986)						
n		5	-	5	-	-
$\bar{x}$		2.553	-	2.556	-	-
s		0.006	-	0.008	-	-
x	01	2.552	-0.17	2.550	-0.75	-0.46
	02	2.554	0.17	2.561	0.63	0.40
	04	2.557	0.67	2.554	-0.25	0.21
	05	2.560	1.17	2.566	1.25	1.21
	06	2.543	-1.67	2.547	-1.13	-1.40

TABLE VIII

CTA CORRELATION - MRD (SD) - HOT MIX STATISTICS

	Material #1	Material #2
ALL (1983)		
n	24	22
$\bar{x}$	2.466	2.470
s	0.018	0.012
Int.*	2.458/2.474(0.016)	2.465/2.475(0.010)
MTC (R) (1983)		
n	5	5
$\bar{x}$	2.478	2.476
s	0.015	0.008
Int.	2.459/2.497(0.038)	2.466/2.486(0.020)
ALL (1984)		
n	27	27
$\bar{x}$	2.478	2.512
s	0.032	0.032
Int.	2.465/2.491(0.026)	2.499/2.525(0.026)
MTC (R) (1984)		
n	5	5
$\bar{x}$	2.494	2.532
s	0.011	0.008
Int.	2.480/2.508(0.028)	2.522/2.542(0.020)
ALL (1985)		
n	28	28
$\bar{x}$	2.488	2.488
s	0.013	0.014
Int.	2.483/2.493(0.010)	2.483/2.493(0.010)
MTC (R) (1985)		
n	4	4
$\bar{x}$	2.497	2.498
s	0.011	0.011
Int.	2.479/2.514(0.036)	2.480/2.516(0.038)
ALL (1986)		
n	28	28
$\bar{x}$	2.502	2.517
s	0.012	0.016
Int.	2.497/2.507(0.010)	2.511/2.523(0.012)
MTC (R) (1986)		
n	5	5
$\bar{x}$	2.510	2.532
s	0.008	0.014
Int.	2.500/2.520(0.020)	2.522/2.542(0.020)

*Int. = 95% confidence range of the mean
**Number in parenthesis is the difference between range limits

TABLE VII A

CTA CORRELATION - HOT MIX - 1983/84

		MRD (SD)				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1983)						
n		24	-	22	-	-
$\bar{x}$		2.466	-	2.470	-	-
s		0.018	-	0.012	-	-
x	01	2.452	-0.78	2.465	-0.40	-0.59
	02	2.486	1.13	2.484	1.14	1.14
	04	2.486	1.13	2.481	0.94	1.04
	05	2.479	0.71	2.476	0.54	0.63
	06	2.488	1.21	2.472	0.21	0.71
MTC (R) (1983)						
n		5	-	5	-	-
$\bar{x}$		2.478	-	2.476	-	-
s		0.015	-	0.008	-	-
x	01	2.452	-1.73	2.465	-1.38	1.56
	02	2.486	0.53	2.484	1.00	0.77
	04	2.486	0.53	2.481	0.63	0.58
	05	2.479	0.07	2.476	0.00	0.04
	06	2.488	0.67	2.472	-0.10	0.09
ALL (1984)						
n		27	-	27	-	-
$\bar{x}$		2.478	-	2.512	-	-
s		0.032	-	0.032	-	-
x	01	2.490	0.39	2.535	0.70	0.54
	02	2.508	0.93	2.544	0.99	0.96
	04	2.491	0.40	2.531	0.59	0.50
	05	2.502	0.73	2.524	0.36	0.55
	06	2.479	0.04	2.528	0.47	0.26
MTC (R) (1984)						
n		5	-	-	-	-
$\bar{x}$		2.494	-	2.532	-	-
s		0.011	-	0.008	-	-
x	01	2.490	-0.36	2.535	0.38	0.01
	02	2.508	1.27	2.544	1.50	1.39
	04	2.491	-0.27	2.531	-0.13	-0.20
	05	2.502	0.73	2.524	-1.00	-0.14
	06	2.479	-1.36	2.528	-0.50	-0.93

TABLE VII B

CTA CORRELATION - HOT MIX - 1985/86

		MRD (SD)				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1985)						
n		28	-	28	-	-
$\bar{x}$		2.488	-	2.488	-	-
s		0.013	-	0.014	-	-
x	01	2.513	1.91	2.512	1.78	1.85
	02	-	-	-	-	-
	04	2.493	0.41	2.490	0.16	0.29
	05	2.493	0.37	2.500	0.90	0.64
	06	2.490	0.11	2.488	0.05	0.08
MTC (R) (1985)						
n		4	-	4	-	-
$\bar{x}$		2.497	-	2.498	-	-
s		0.011	-	0.011	-	-
x	01	2.513	1.45	2.512	1.27	1.36
	02	-	-	-	-	-
	04	2.493	-0.36	2.490	-0.73	-0.55
	05	2.493	-0.36	2.500	+0.18	-0.09
	06	2.490	-0.64	2.488	-0.91	-0.78
ALL (1986)						
n		28	-	28	-	-
$\bar{x}$		2.502	-	2.517	-	-
s		0.012	-	0.016	-	-
x	01	2.504	0.16	2.527	0.63	0.40
	02	2.518	1.24	2.537	1.22	1.23
	04	2.517	1.20	2.534	1.04	1.12
	05	2.500	-0.16	2.519	0.08	-0.04
	06	2.513	0.84	2.525	0.45	0.65
MTC (R) (1986)						
n		5	-	5	-	-
$\bar{x}$		2.510	-	2.532	-	-
s		0.008	-	0.014	-	-
x	01	2.504	-0.75	2.527	-0.36	0.56
	02	2.518	1.00	2.537	0.36	0.68
	04	2.517	0.88	2.534	0.14	0.51
	05	2.500	-1.75	2.519	-0.93	-1.09
	06	2.513	0.38	2.525	-0.50	-0.06

TABLE XIII

CTA CORRELATION - BRD - HOT MIX - MTC (A) vs MTC (M)

	Material #1	Material #2
MTC (A)(1983)		
n	12	12
$\bar{x}$	2.350	2.382
s	0.009	0.009
MTC (M) (1983)		
n	7	7
$\bar{x}$	2.346	2.381
s	0.009	0.010
MTC (A) (1984)		
n	11	11
$\bar{x}$	2.411	2.420
s	0.012	0.017
MTC (M) (1984)		
n	6	6
$\bar{x}$	2.410	2.412
s	0.016	0.018
MTC (A) (1985)		
n	12	12
$\bar{x}$	2.405	2.396
s	0.013	0.012
MTC (M) (1985)		
n	7	7
$\bar{x}$	2.401	2.394
s	0.016	0.014
MTC (A) (1986)		
n	11	11
$\bar{x}$	2.402	2.439
s	0.014	0.011
MTC (M) (1986)		
n	6	6
$\bar{x}$	2.392	2.434
s	0.010	0.010

TABLE IX

BITUMINOUS CONCRETE - AMRL AND CAE CORRELATIONS - MARSHALL STABILITY

Correlation Sample	AMRL #3	AMRL #4	CAE Hand	CAE Mechanical
ALL (1983)				
n	-	-	25	21
$\bar{x}$	-	-	9000	10200
s	-	-	1700	1500
Downsview				
x	-	-	11600	10800
S.D.*	-	-	1.53	0.40
ALL (1984)				
n	-	-	27	24
$\bar{x}$	-	-	11500	10400
s	-	-	1400	2200
Downsview				
x	-	-	13800	12700
S.D.*	-	-	1.64	1.05
ALL (1985)				
n	88	88	30	28
$\bar{x}$	6210	5956	7900	7700
s	1484	1439	1500	1400
Downsview				
x	7967	7998	10500	13000
S.D.*	1.18	1.42	1.73	3.79**

*S.D. = Standardized Deviate

**Data discarded in correlation. Mechanical Marshall Stabilities are not plotted herein but do show the same Trend as the Hand Stabilities.

TABLE X A

CTA CORRELATION - HOT MIX - 1983/84

		Marshall Stability				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1983)						
n		33	-	33	-	-
$\bar{x}$		4374	-	6139	-	-
s		1348	-	1434	-	-
x	01	4794	0.31	6529	0.27	0.29
	02	3672	-0.52	5761	-0.26	-0.39
	04	5038	0.49	8155	1.41	0.95
	05	5706	0.99	9057	2.03	1.51
	06	5587	0.86	6613	0.33	0.60
MTC (R) (1983)						
n		5	-	5	-	-
$\bar{x}$		4949	-	7223	-	-
s		803	-	1344	-	-
x	01	4794	-0.19	6529	-0.52	-0.36
	02	3672	-1.59	5761	-1.09	-1.34
	04	5038	0.11	8155	0.69	0.40
	05	5706	0.94	9057	1.36	1.15
	06	5537	0.73	6613	-0.45	0.14
ALL (1984)						
n		34	-	34	-	-
$\bar{x}$		11929	-	11961	-	-
s		2209	-	2135	-	-
x	01	13072	0.52	13389	0.67	0.60
	02	12970	0.47	12770	0.38	0.43
	04	13958	0.92	15214	1.52	1.22
	05	13952	0.92	14398	1.14	1.03
	06	15211	1.49	14924	1.39	1.44
MTC (R) (1984)						
n		5	-	5	-	-
$\bar{x}$		13833	-	14139	-	-
s		902	-	1034	-	-
x	01	13072	-0.84	13389	-0.73	-0.79
	02	12970	-0.96	12770	-1.32	-1.14
	04	13958	0.14	15214	1.04	0.59
	05	13952	0.13	14398	0.25	0.19
	06	15211	1.53	14924	0.76	1.15

TABLE X B

CTA CORRELATION - HOT MIX - 1985/86

		Marshall Stability				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1985)						
n		37	-	39	-	-
$\bar{x}$		10017	-	8298	-	-
s		1850	-	1774	-	-
x	01	14723	2.54	11404	1.75	2.15
	02	10079	0.03	8641	0.19	0.11
	04	11668	0.89	10379	1.17	1.03
	05	7453	-1.39	6596	-0.96	-1.18
	06	11914	1.03	10276	1.11	1.07
MTC (R) (1985)						
n		5	-	5	-	-
$\bar{x}$		11167	-	9459	-	-
s		2666	-	1881	-	-
x	01	14723	1.33	11404	1.03	1.18
	02	10079	-0.41	8641	-0.43	-0.42
	04	11668	0.19	10379	0.49	0.34
	05	7453	-1.39	6596	-1.52	-1.46
	06	11914	0.28	10276	0.43	0.36
ALL (1986)						
n		35	-	30	-	-
$\bar{x}$		12405	-	13564	-	-
s		2886	-	1450	-	-
x	01	18434	2.08	19845	-	2.08*
	02	18709	2.17	18438	-	2.17*
	04	13736	0.45	15648	1.43	0.95
	05	12391	0.00	14959	0.95	0.48
	06	16775	1.50	19082	-	1.50*
MTC (R) (1986)						
n		5	-	5	-	-
$\bar{x}$		16009	-	17594	-	-
s		2829	-	2164	-	-
x	01	18434	0.86	19845	1.04	0.95
	02	18709	0.95	18438	0.39	0.67
	04	13736	-0.80	15648	-0.90	-0.85
	05	12391	-1.28	14959	-1.22	-1.25
	06	16775	0.27	19082	0.69	0.48

*Only one datum point.

TABLE XI

CTA CORRELATION - MARSHALL STABILITY - HOT MIX - STATISTICS

	Material #1	Material #2
ALL (1983)		
n	33	33
$\bar{x}$	4374	6139
s	1348	1434
Int.*	3896/4852(960)**	5630/6648(1018)
MTC (R) (1983)		
n	5	5
$\bar{x}$	4949	7223
s	803	1344
Int.	3952/5946(1994)	5554/8892(3338)
ALL (1984)		
n	34	34
$\bar{x}$	11929	11961
s	2209	2135
Int.	11158/12700(1542)	11216/12706(1490)
MTC (R) (1984)		
n	5	5
$\bar{x}$	13833	14139
s	902	1034
Int.	12713/14953(2240)	12855/15423(2568)
ALL (1985)		
n	37	39
$\bar{x}$	10017	8298
s	1850	1774
Int.	9400/10634(1234)	7723/8873(1150)
MTC (R) (1985)		
n	5	5
$\bar{x}$	11167	9459
s	2666	1881
Int.	7857/14477(6620)	7124/11794(4670)
ALL (1986)		
n	35	30
$\bar{x}$	12405	13564
s	2886	1450
Int.	11412/13397(1985)	13023/14105(1082)
MTC (R) (1986)		
n	5	5
$\bar{x}$	16009	17594
s	2829	2164
Int.	12497/19521(7024)	14907/20281(5374)

*Int. = 95% confidence range of the mean
**Number in parenthesis is the difference between the range limits

TABLE XII A

CTA CORRELATION - HOT MIX - 1983/84

		MARSHALL FLOWS				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1983)						
n		34	-	34	-	-
$\bar{x}$		7.27	-	7.85	-	-
s		1.36	-	1.32	-	-
x	01	6.80	-0.35	7.55	-0.23	-0.29
	02	6.75	-0.38	7.90	0.04	-0.17
	04	6.50	-0.57	7.20	-0.49	0.53
	05	9.00	1.28	10.55	2.05	1.67
	06	6.35	-0.68	6.45	-1.06	-0.87
MTC (R) (1983)						
n		5	-	5	-	-
$\bar{x}$		7.08	-	7.93	-	-
s		1.09	-	1.56	-	-
x	01	6.80	-0.26	7.55	-0.24	-0.25
	02	6.75	-0.30	7.90	-0.02	-0.16
	04	6.50	-0.53	7.20	-0.47	-0.50
	05	9.00	1.76	10.55	1.68	1.72
	06	6.35	-00.67	6.45	-0.95	-0.81
ALL (1984)						
n		34	-	34	-	-
$\bar{x}$		10.25	-	9.47	-	-
s		1.48	-	2.13	-	-
x	01	9.45	-0.54	8.25	-0.51	-0.53
	02	10.90	0.44	9.15	-0.15	0.15
	04	10.15	-0.07	10.30	0.39	0.16
	05	13.25	2.03	11.65	1.02	1.53
	06	10.30	0.03	8.95	-0.25	-0.11
MTC (R) (1984)						
n		5	-	-	-	-
$\bar{x}$		10.81	-	9.72	-	-
s		1.46	-	1.26	-	-
x	01	9.45	-0.93	8.25	-1.17	-1.05
	02	10.90	0.06	9.15	-0.45	-0.20
	04	10.15	-0.45	10.20	0.46	0.01
	05	13.35	1.67	11.65	1.53	1.60
	06	10.30	-0.35	8.95	-0.61	-0.48

TABLE XII B

CTA CORRELATION - HOT MIX - 1985/86

		MARSHALL FLOWS				
		Mat. 1		Mat. 2		Average
Laboratories		Data	S.D.	Data	S.D.	S.D.
ALL (1985)						
n		38	-	38	-	-
$\bar{x}$		9.35	-	8.44	-	-
s		1.25	-	1.07	-	-
x	01	9.90	0.44	8.45	0.01	0.23
	02	8.42	-0.74	7.65	-0.74	-0.74
	04	9.00	-0.28	7.85	-0.55	-0.42
	05	8.75	-0.48	7.85	-0.55	-0.52
	06	9.05	-0.24	8.30	-0.13	-0.19
MTC (R) (1985)						
n		5	-	5	-	-
$\bar{x}$		9.02	-	8.02	-	-
s		0.55	-	0.34	-	-
x	01	9.90	1.59	8.45	1.27	1.43
	02	8.42	-1.10	7.65	-1.09	-1.10
	04	9.00	-0.04	7.85	-0.05	-0.27
	05	8.75	-0.50	7.85	-0.50	-0.50
	06	9.05	0.50	8.30	0.83	0.44
ALL (1986)						
n		33	-	33	-	-
$\bar{x}$		9.81	-	10.35	-	-
s		1.17	-	1.33	-	-
x	01	10.45	0.55	10.80	0.33	0.44
	02	11.65	1.56	12.45	1.58	1.57
	04	8.35	-1.25	10.15	-0.16	-0.71
	05	10.30	0.42	10.30	-0.40	-0.19
	06	9.50	-0.27	10.55	0.15	-0.06
MTC (R) (1986)						
n		5	-	5	-	-
$\bar{x}$		10.05	-	10.85	-	-
s		1.22	-	0.93	-	-
x	01	10.45	0.33	10.80	0.05	0.14
	02	11.65	1.31	12.45	1.72	1.52
	04	8.35	-1.39	10.15	-0.75	-1.07
	05	10.30	0.20	10.30	-0.59	-0.20
	06	9.50	-0.45	10.55	-0.32	-0.39

TABLE XVIII

CTA CORRELATION - HOT MIX - 1983 to 1986
(summary of differences of MTC vs ALL laboratories)

Laboratories	1983	1984	1985	1986	Overall Average
		MRD (SD)			
MTC (A) Mat.1	0.006	0.012	0.004	0.006	
Mat.2	0.005	0.019	0.005	0.007	
(Average)	0.006	0.016	0.005	0.007	0.009
MTC (R) Mat.1	0.012	0.016	0.009	0.008	
Mat.2	0.006	0.020	0.010	0.015	
(Average)	0.009	0.018	0.010	0.012	0.012
MTC (M) Mat.1	0.002	0.006	0.004	0.002	
Mat.2	0.004	0.018	0.000	0.003	
(Average)	0.003	0.012	0.002	0.003	0.005
		MARSHALL STABILITY*			
MTC (A) Mat.1	6.93	7.21	6.12	8.48	
Mat.2	8.96	6.50	9.36	13.33	
(Average)	7.95	6.86	7.74	10.91	8.37
MTC (R) Mat.1	11.62	13.76	10.30	22.51	
Mat.2	15.01	15.40	12.27	22.91	
(Average)	13.32	14.58	11.29	22.71	15.48
MTC (M) Mat.1	3.27	0.95	3.79	-7.78	
Mat.2	8.80	-2.48	7.16	3.32	
(Average)	6.04	-0.77	5.48	02.23	4.26

*Expressed as percentage by which laboratory data must be reduced to give ALL laboratory mean values.

TABLE XIV

CTA CORRELATION - MRD - HOT MIX - MTC (A) vs MTC (M)

	Material #1	Material #2
MTC (A)(1983)		
n	12	12
$\bar{x}$	2.491	2.489
s	0.009	0.008
MTC (M) (1983)		
n	7	7
$\bar{x}$	2.486	2.486
s	0.008	0.009
MTC (A) (1984)		
n	10	10
$\bar{x}$	2.535	2.559
s	0.005	0.004
MTC (M) (1984)		
n	5	5
$\bar{x}$	2.535	2.558
s	0.005	0.005
MTC (A) (1985)		
n	11	11
$\bar{x}$	2.538	2.528
s	0.006	0.009
MTC (M) (1985)		
n	7	7
$\bar{x}$	2.531	2.523
s	0.009	0.008
MTC (A) (1986)		
n	11	11
$\bar{x}$	2.549	2.552
s	0.006	0.008
MTC (M) (1986)		
n	6	6
$\bar{x}$	2.545	2.549
s	0.004	0.008

TABLE XV

CTA CORRELATION - MRD (SD) - HOT MIX - MTC (A) vs MTC (M)

	Material #1	Material #2
MTC (A)(1983)		
n	9	9
$\bar{x}$	2.472	2.475
s	0.018	0.007
MTC (M) (1983)		
n	4	4
$\bar{x}$	2.464	2.474
s	0.010	0.007
MTC (A) (1984)		
n	9	9
$\bar{x}$	2.490	2.531
s	0.011	0.007
MTC (M) (1984)		
n	4	4
$\bar{x}$	2.484	2.530
s	0.011	0.005
MTC (A) (1985)		
n	8	8
$\bar{x}$	2.492	2.493
s	0.006	0.010
MTC (M) (1985)		
n	5	5
$\bar{x}$	2.492	2.488
s	0.007	0.007
MTC (A) (1986)		
n	8	8
$\bar{x}$	2.508	2.524
s	0.009	0.009
MTC (M) (1986)		
n	3	3
$\bar{x}$	2.504	2.520
s	0.012	0.010

TABLE XVI

CTA CORRELATION - MARSHALL STABILITY - HOT MIX - MTC (A) vs MTC (M)

	Material #1	Material #2
MTC (A)(1983)		
n	12	11
$\bar{x}$	4700	6743
s	568	659
MTC (M) (1983)		
n	7	7
$\bar{x}$	4522	6731
s	928	468
MTC (A) (1984)		
n	11	11
$\bar{x}$	12856	12793
s	1568	2034
MTC (M) (1984)		
n	6	6
$\bar{x}$	12043	11672
s	1588	2025
MTC (A) (1985)		
n	12	12
$\bar{x}$	10227	9155
s	2173	1797
MTC (M) (1985)		
n	7	7
$\bar{x}$	10412	8938
s	1909	1852
MTC (A) (1986)		
n	11	11
$\bar{x}$	13554	15650
s	2447	2710
MTC (M) (1986)		
n	6	6
$\bar{x}$	11510	14030
s	2515	2004

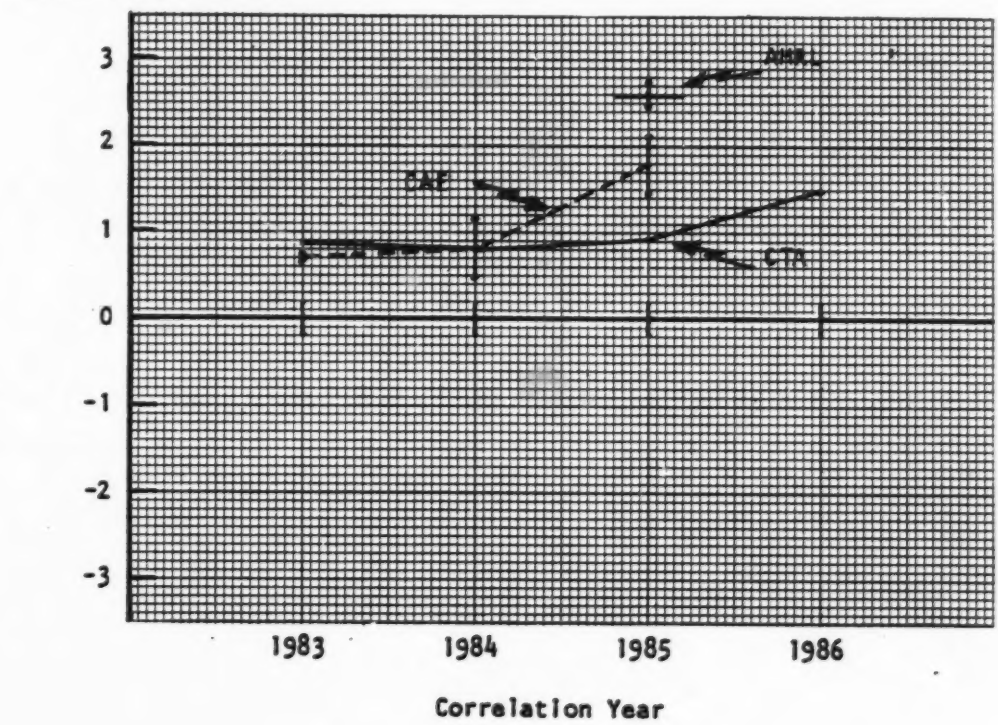
TABLE XVII

CTA CORRELATION - HOT MIX - 1983 to 1986
(summary of differences of MTC vs ALL laboratories)

Laboratories	1983	1984	1985	1986	Overall Average
		BRD			
MTC (A) Mat.1	0.014	0.227	0.010	0.018	
Mat.2	0.021	0.024	0.014	0.027	
(Average)	0.018	0.026	0.012	0.023	0.019
MTC (R) Mat.1	0.018	0.029	0.016	0.031	
Mat.2	0.021	0.034	0.018	0.034	
(Average)	0.020	0.032	0.017	0.037	0.025
MTC (M) Mat.1	0.010	0.026	0.006	0.008	
Mat.2	0.020	0.016	0.012	0.022	
(Average)	0.015	0.021	0.009	0.015	0.015
		MRD			
MTC (A) Mat.1	0.006	0.010	0.009	0.008	
Mat.2	0.004	0.012	0.005	0.004	
(Average)	0.005	0.011	0.007	0.006	0.007
MTC (R) Mat.1	0.012	0.009	0.013	0.012	
Mat.2	0.007	0.012	0.012	0.008	
(Average)	0.010	0.011	0.013	0.010	0.011
MTC (M) Mat.1	0.001	0.010	0.002	0.004	
Mat.2	0.001	0.011	0.000	0.001	
(Average)	0.001	0.011	0.001	0.003	0.004

COMPARISON OF DATA FROM DIFFERENT CORRELATIONS

Figure 1: Bulk Relative Density , Downsview (mix design)



CTA CORRELATION DATA

Figure 2: Bulk Relative Density , Thunder Bay

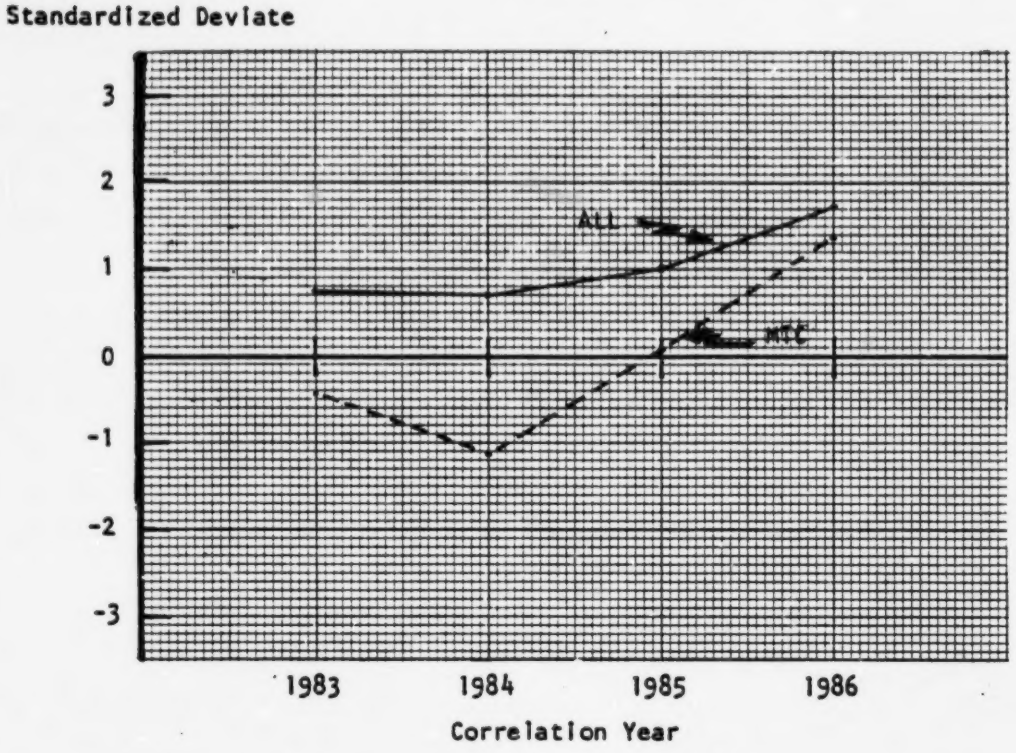
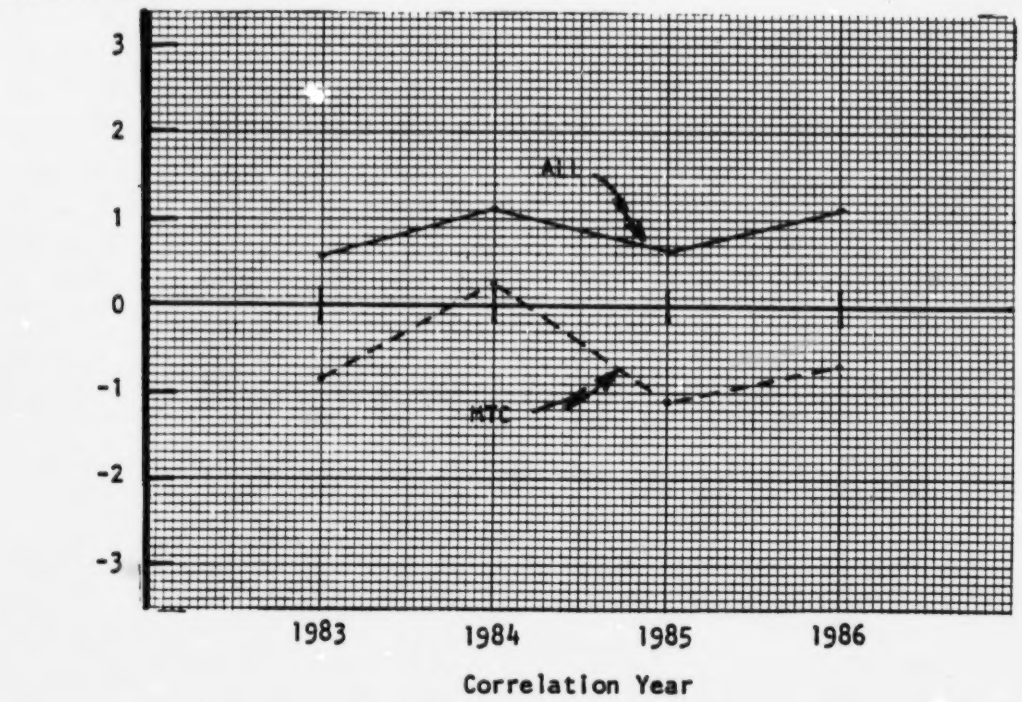


Figure 3: Bulk Relative Density , North Bay



CTA CORRELATION DATA

Figure 4: Bulk Relative Density , Eastern

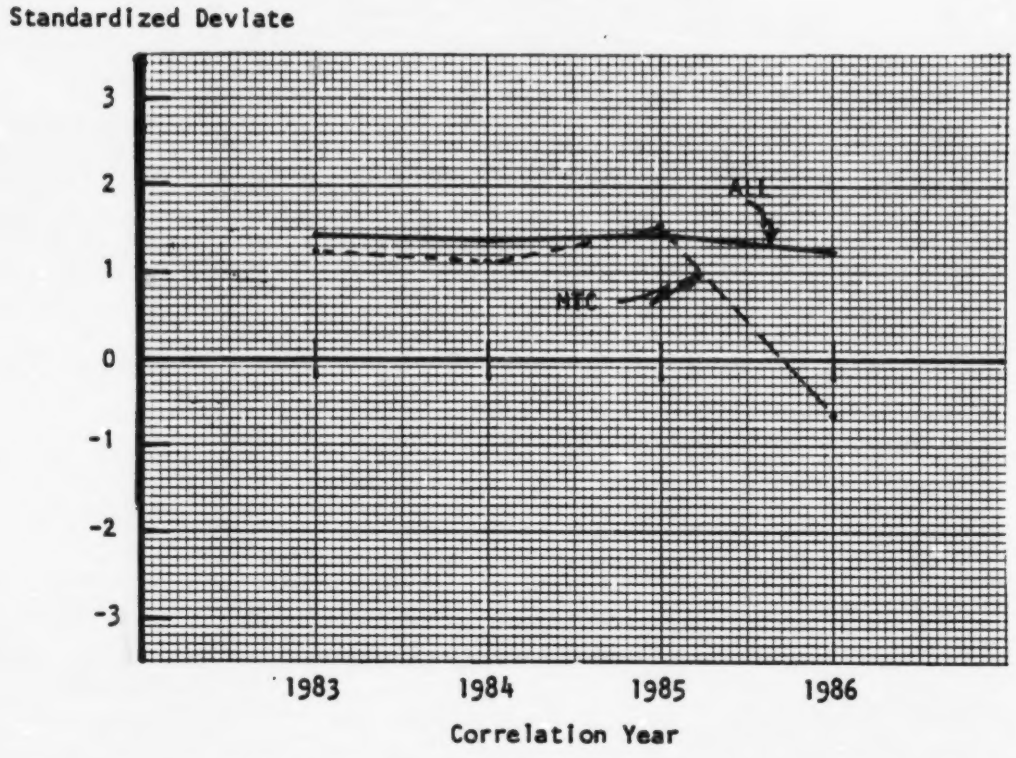
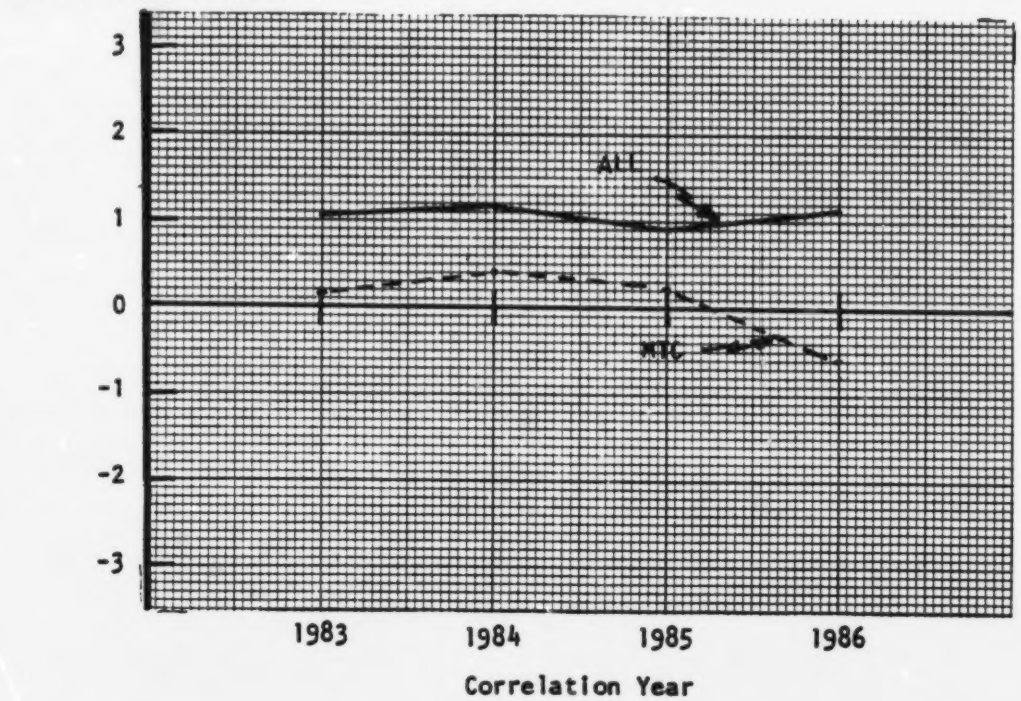
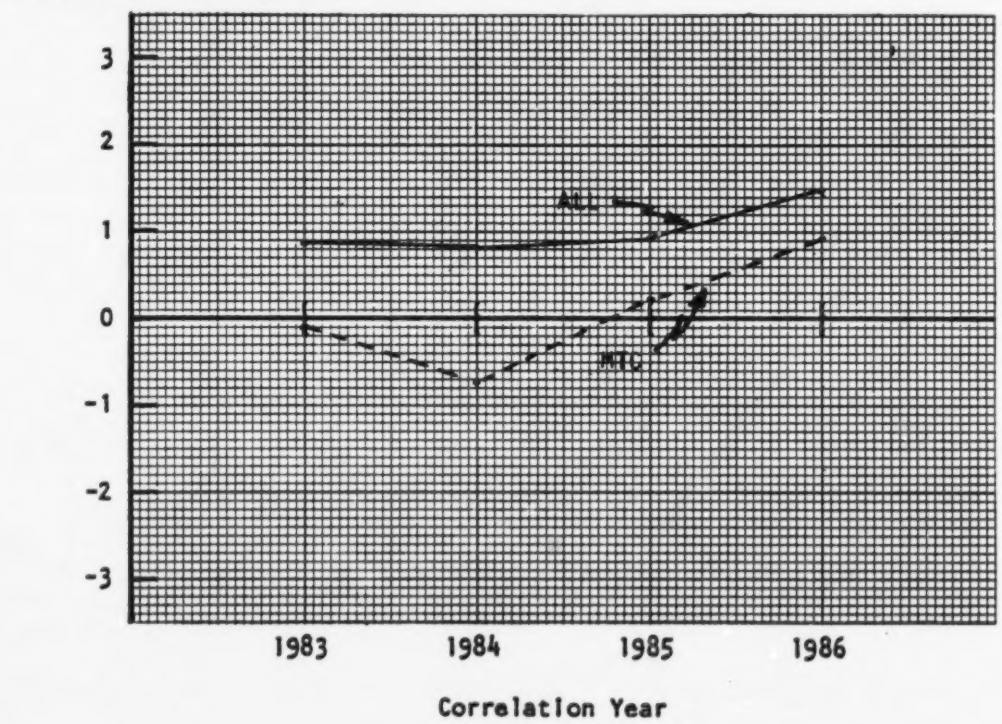


Figure 5: Bulk Relative Density , London



CTA CORRELATION DATA

Figure 6: Bulk Relative Density , Downsview (mix design)



COMPARISON OF DATA FROM DIFFERENT CORRELATIONS

Figure 7: Maximum Relative Density , Downsview (mix design)

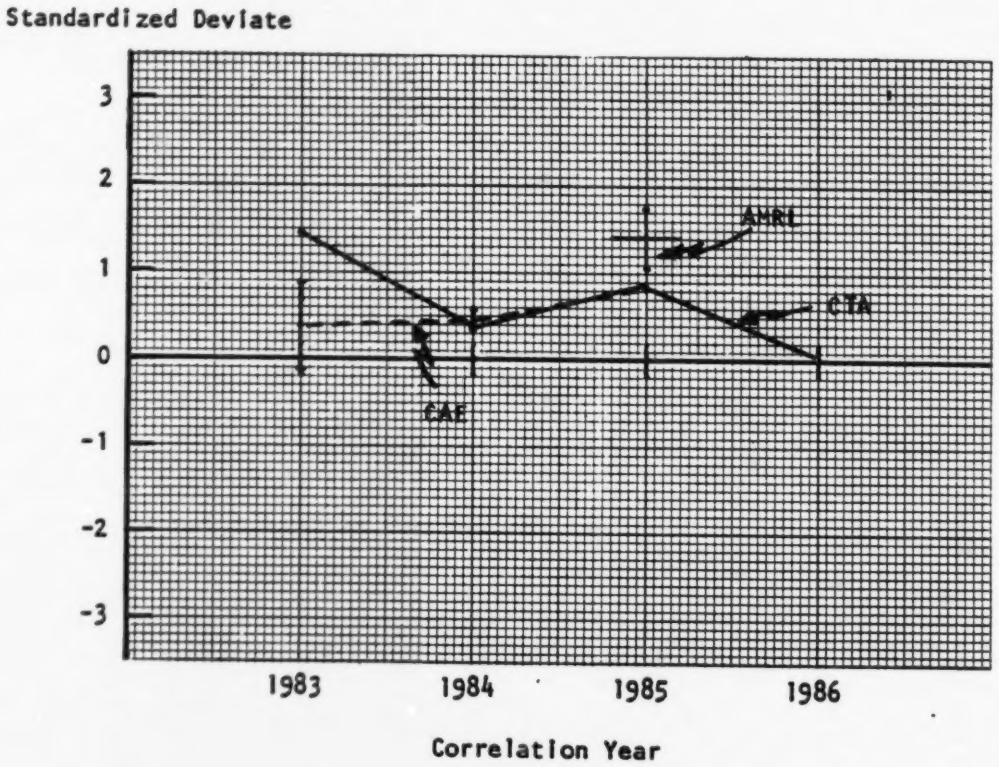


Figure 8: Maximum Relative Density, Thunder Bay

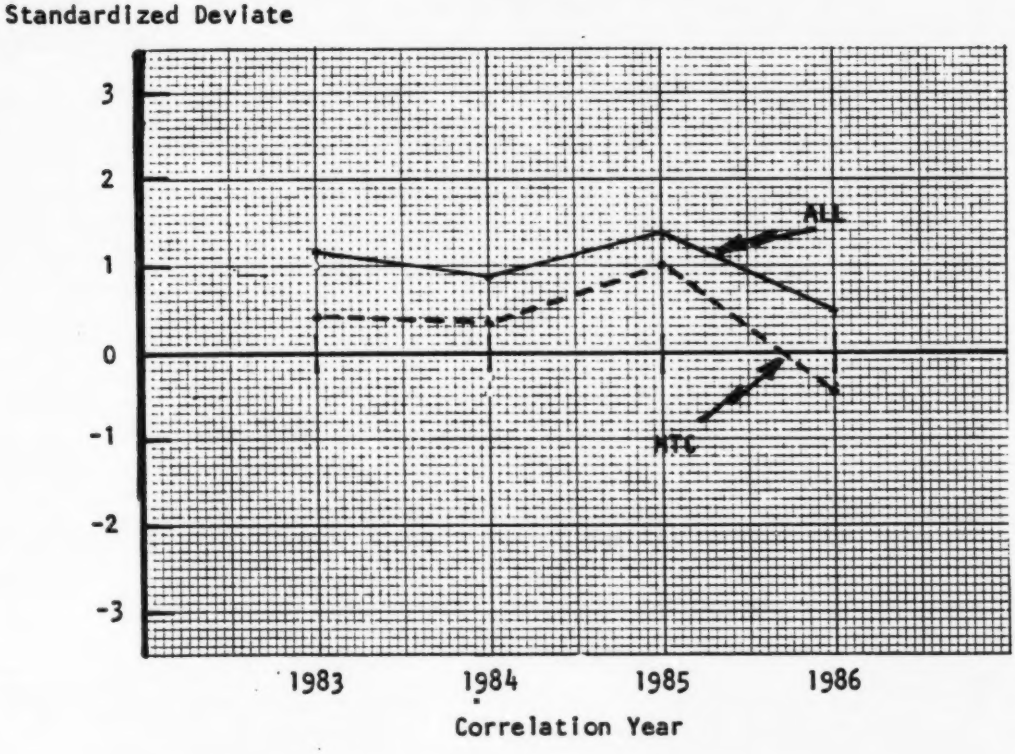
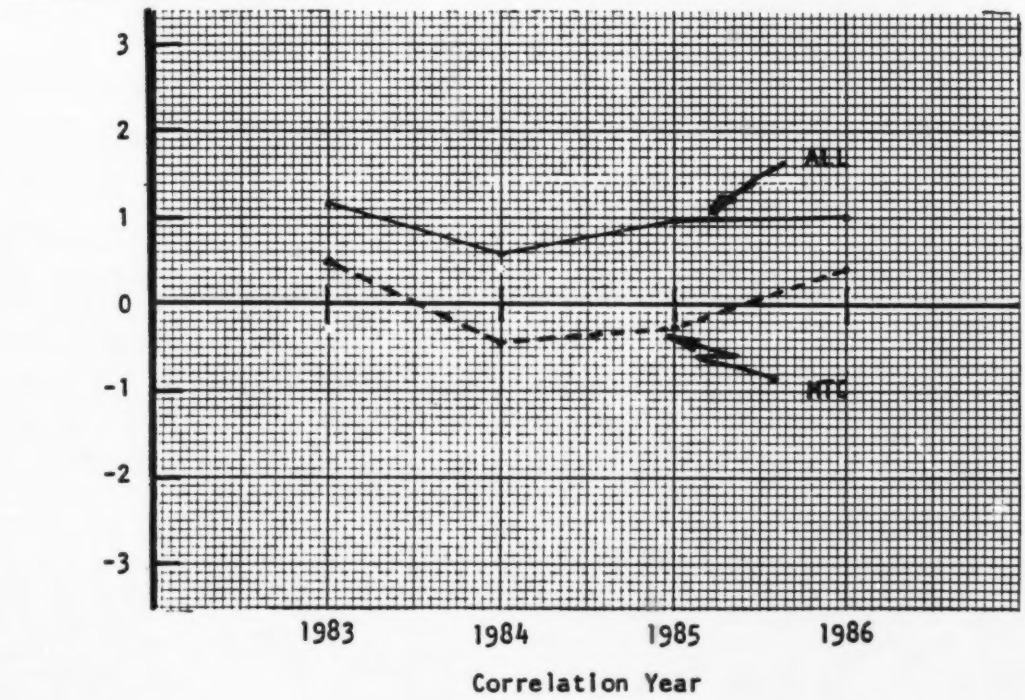


Figure 9: Maximum Relative Density, North Bay



CTA CORRELATION DATA

Figure 10: Maximum Relative Density, Eastern

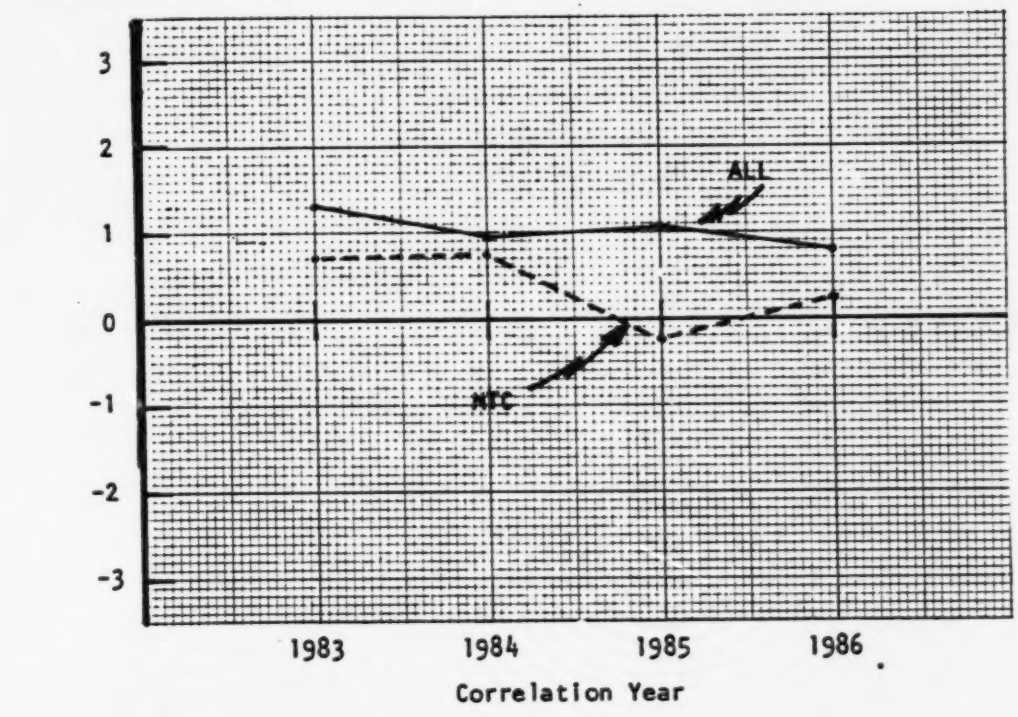


Figure 11: Maximum Relative Density, London

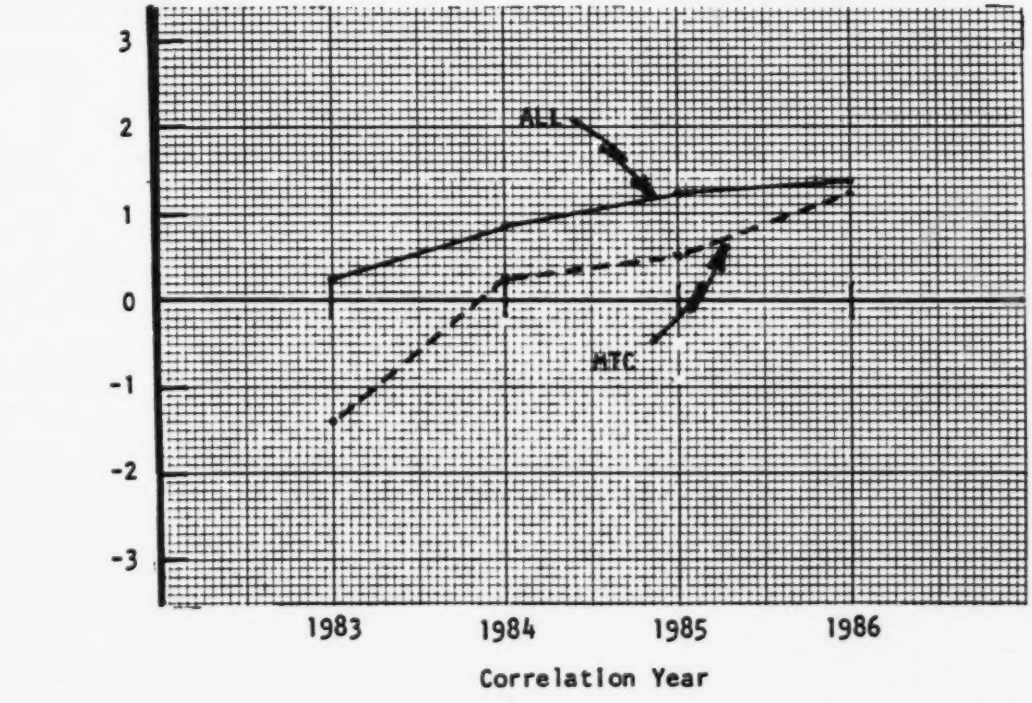


Figure 12: Maximum Relative Density, Downsview (mix design)

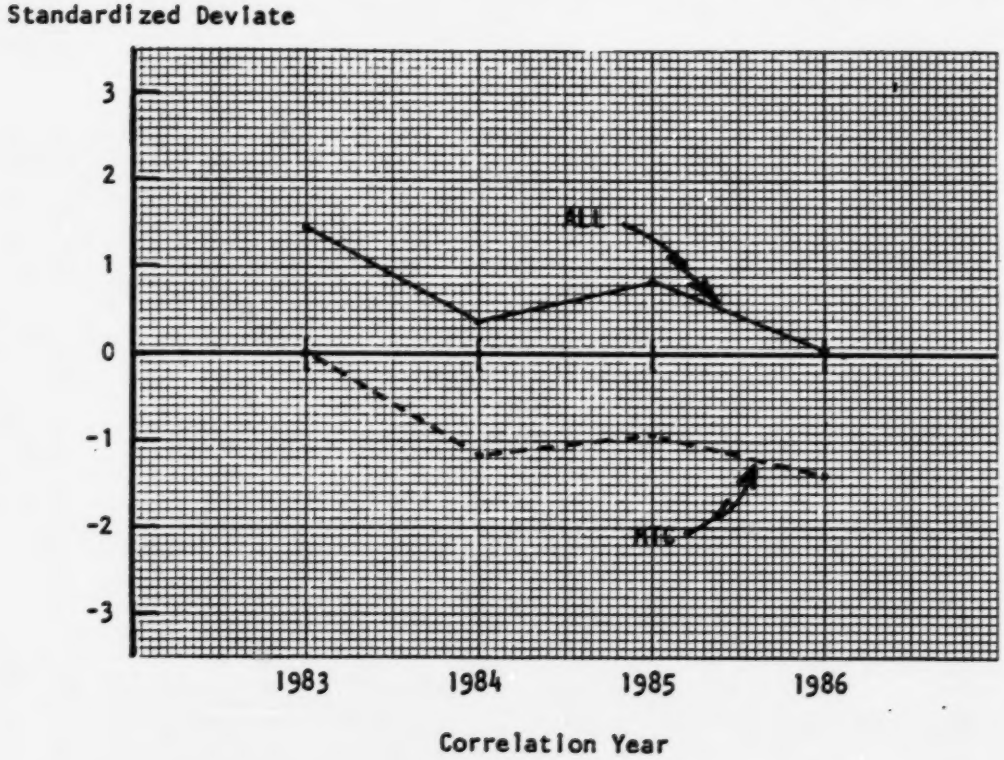


Figure 13: Maximum Relative Density (SD), Thunder Bay

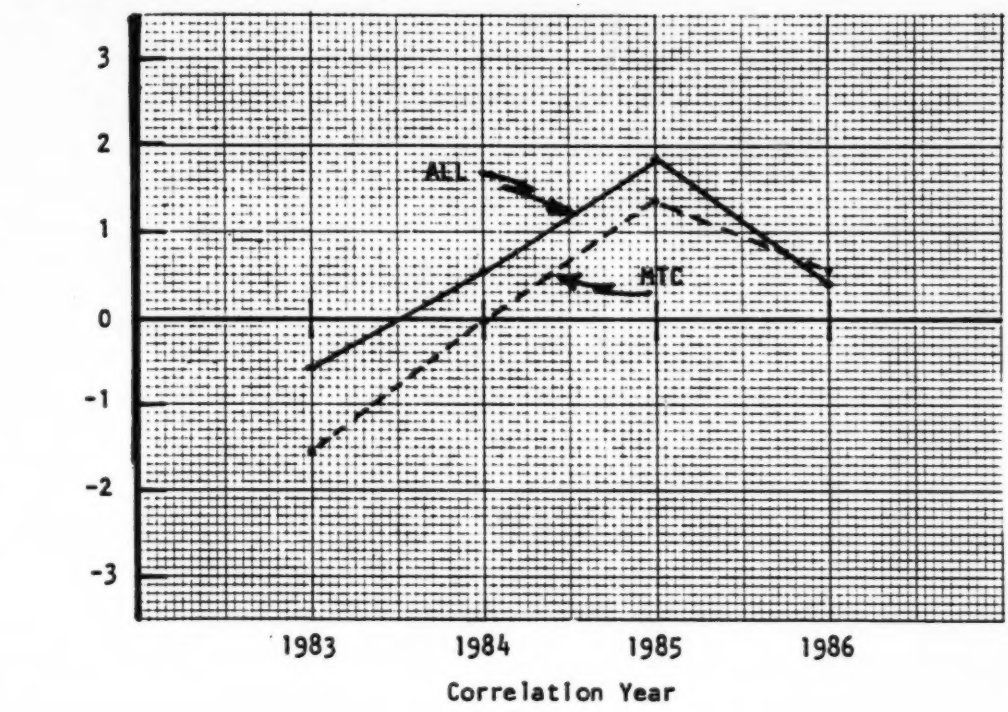
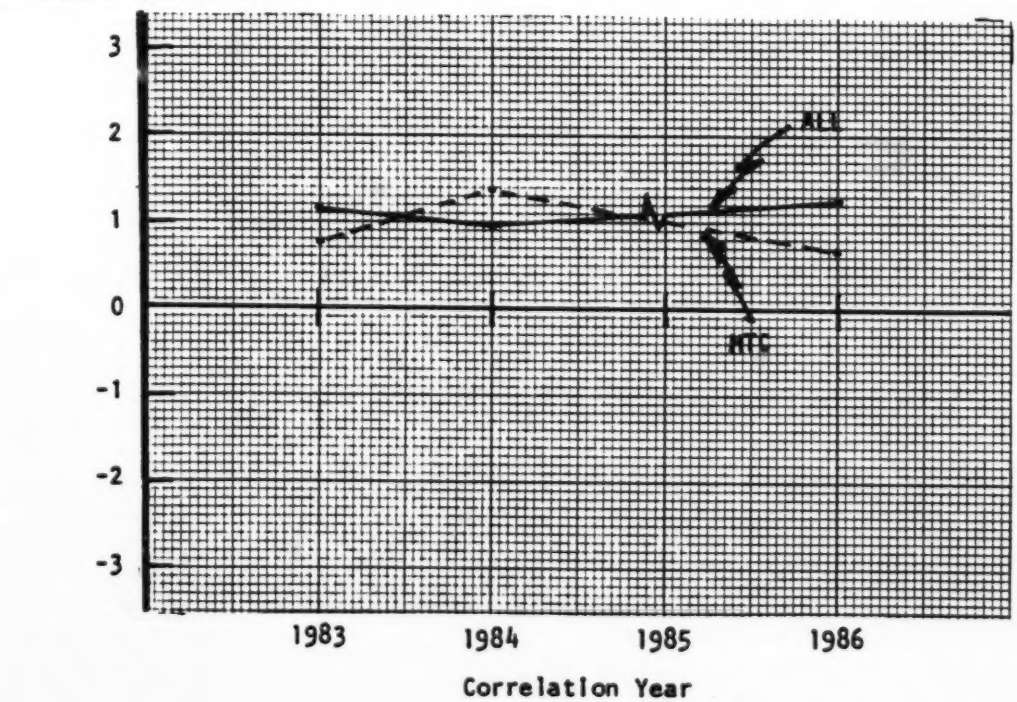


Figure 14: Maximum Relative Density (SD), North Bay



CTA CORRELATION DATA

Figure 15: Maximum Relative Density (SD), Eastern

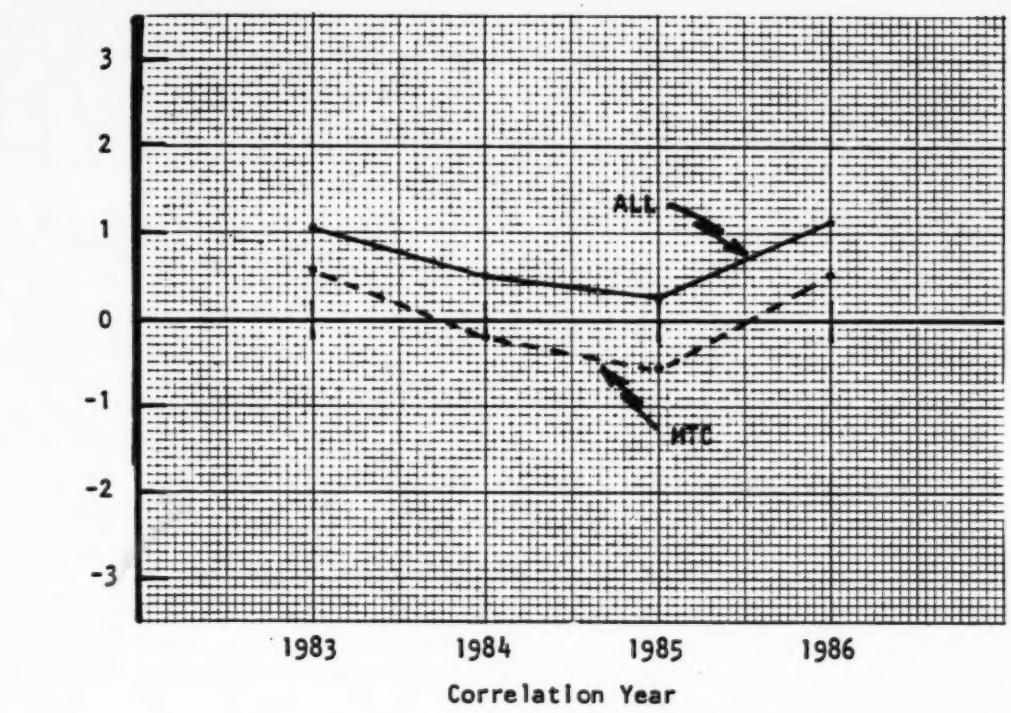
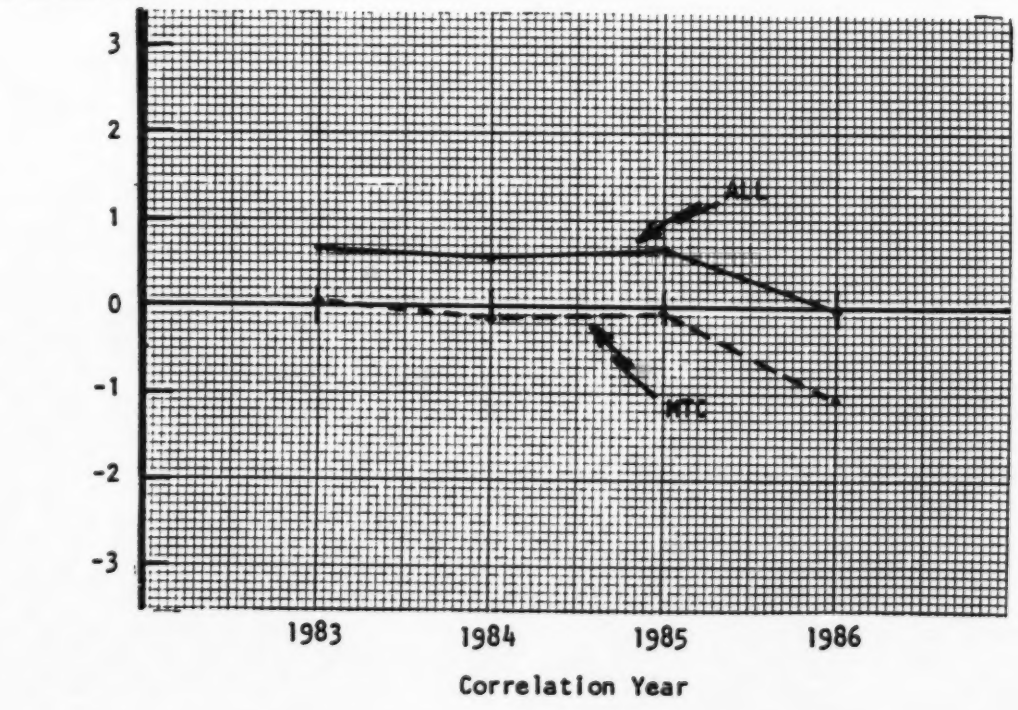
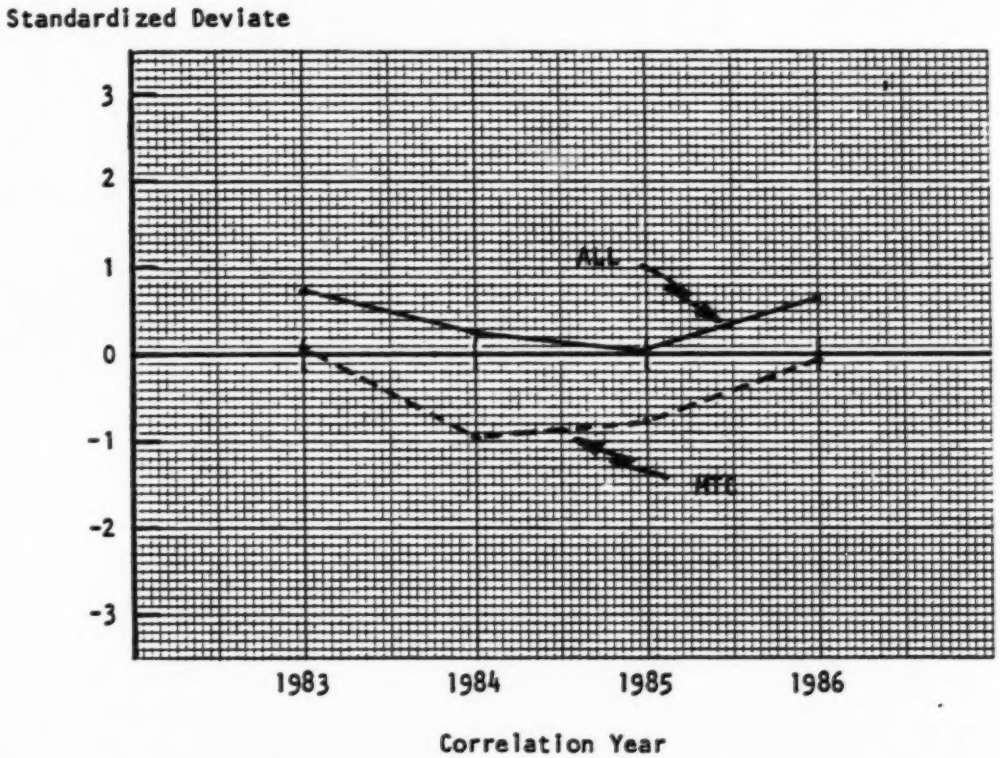


Figure 16: Maximum Relative Density (SD), London



CTA CORRELATION DATA

Figure 17: Maximum Relative Density (SD), Downsview (mix design)



COMPARISON OF DATA FROM DIFFERENT CORRELATIONS

Figure 18: Marshall Stability , Downsview (mix design)

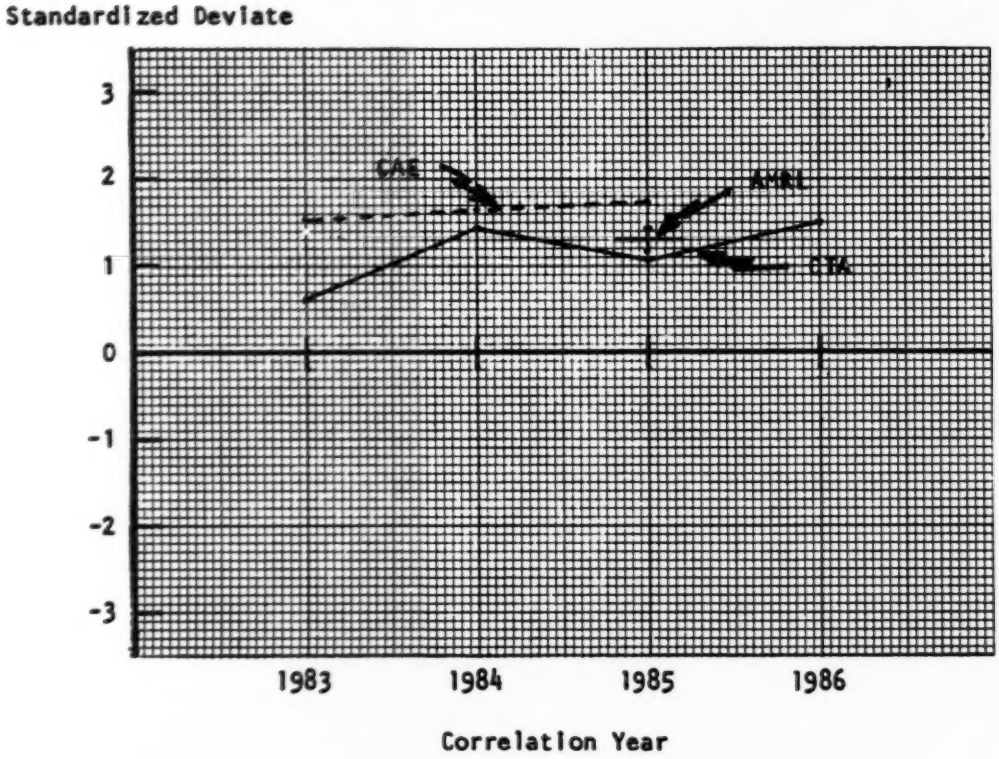


Figure 19: Marshall Stability, Thunder Bay

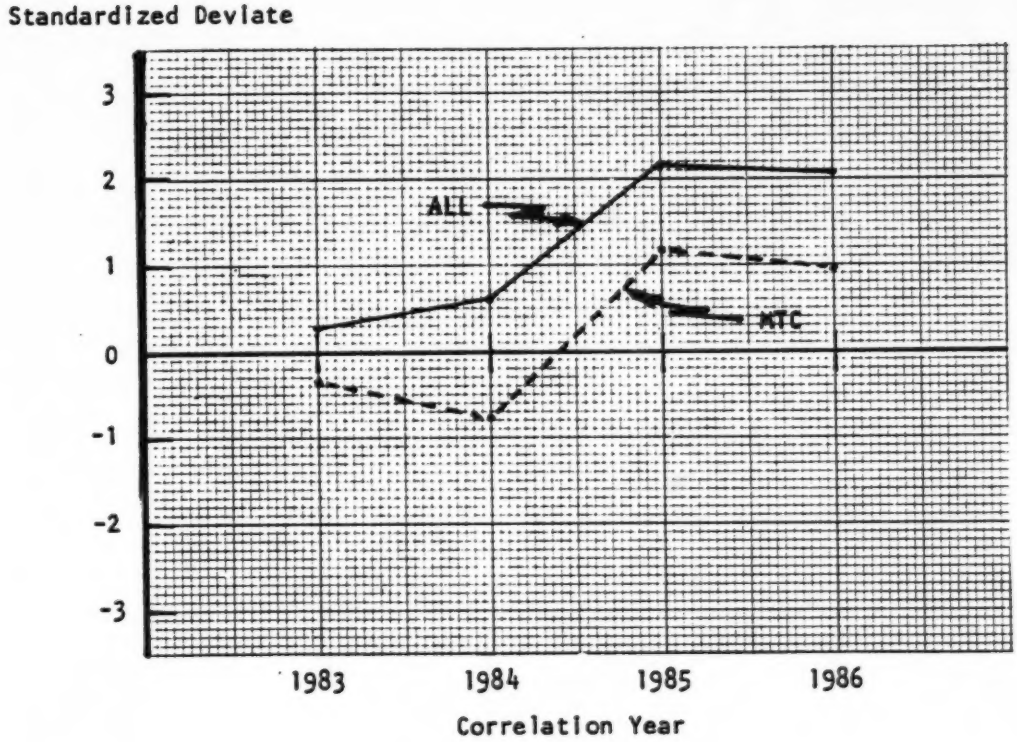


Figure 20: Marshall Stability, North Bay

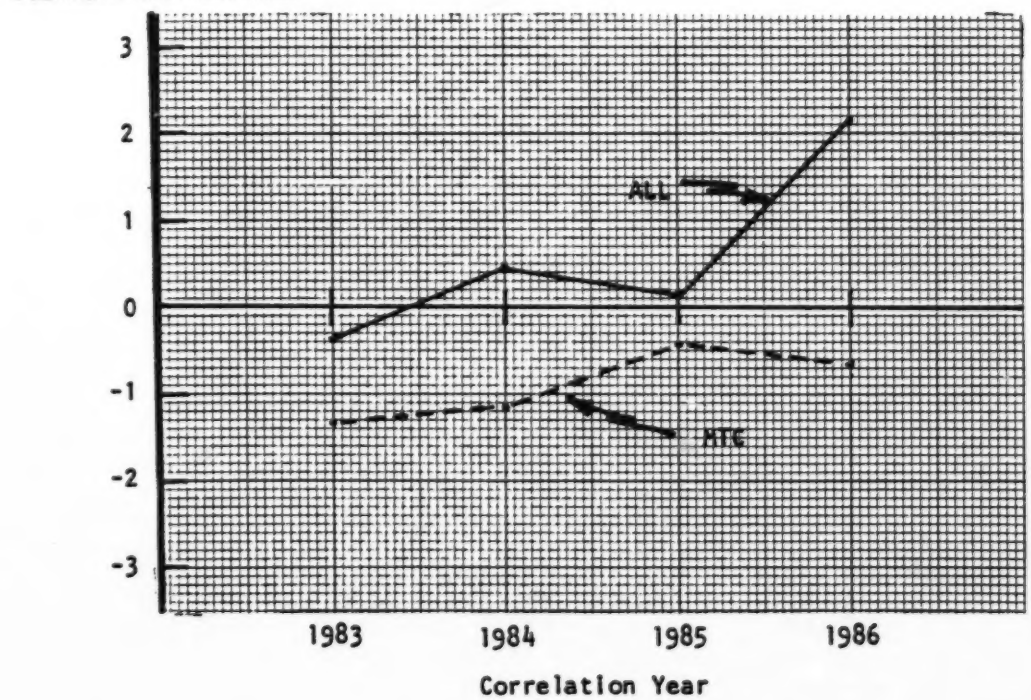


Figure 21: Marshall Stability, Eastern

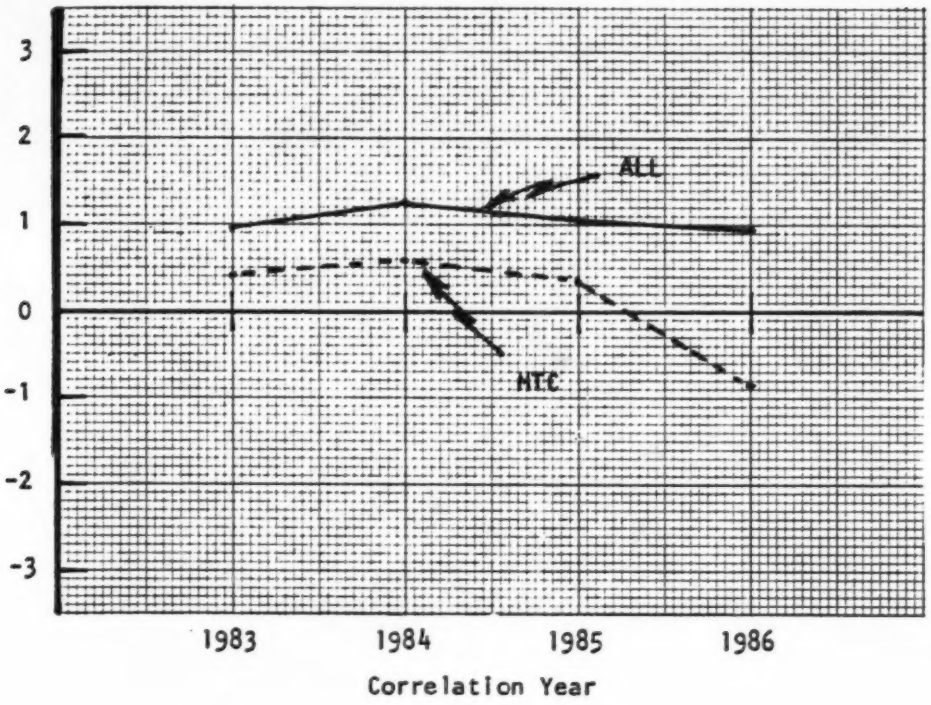
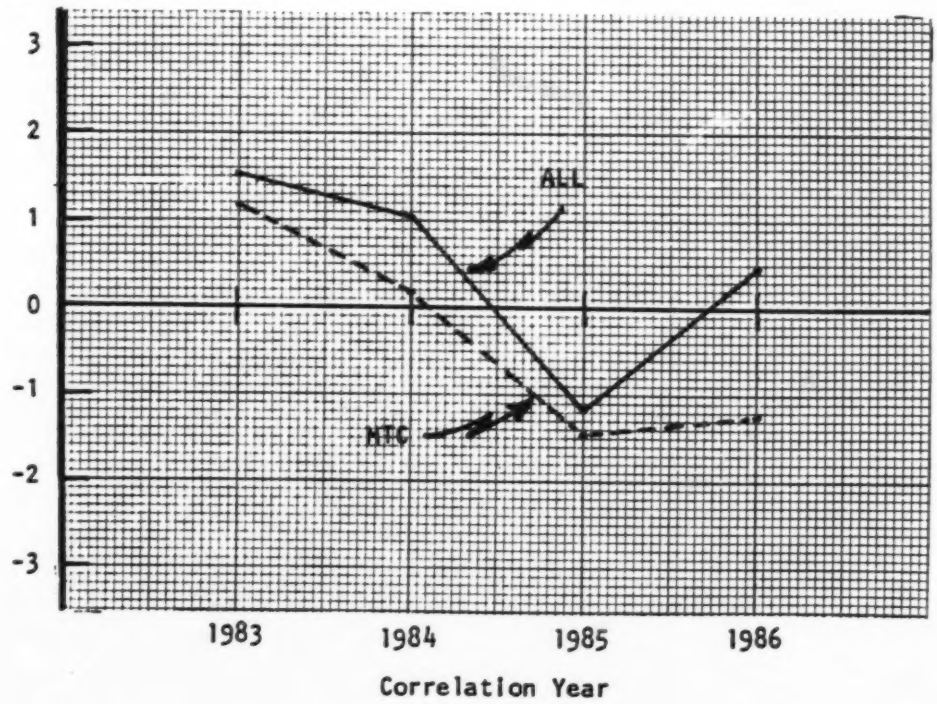


Figure 22: Marshall Stability, London



CTA CORRELATION DATA

Figure 23: Marshall Stability, Downsview (mix design)

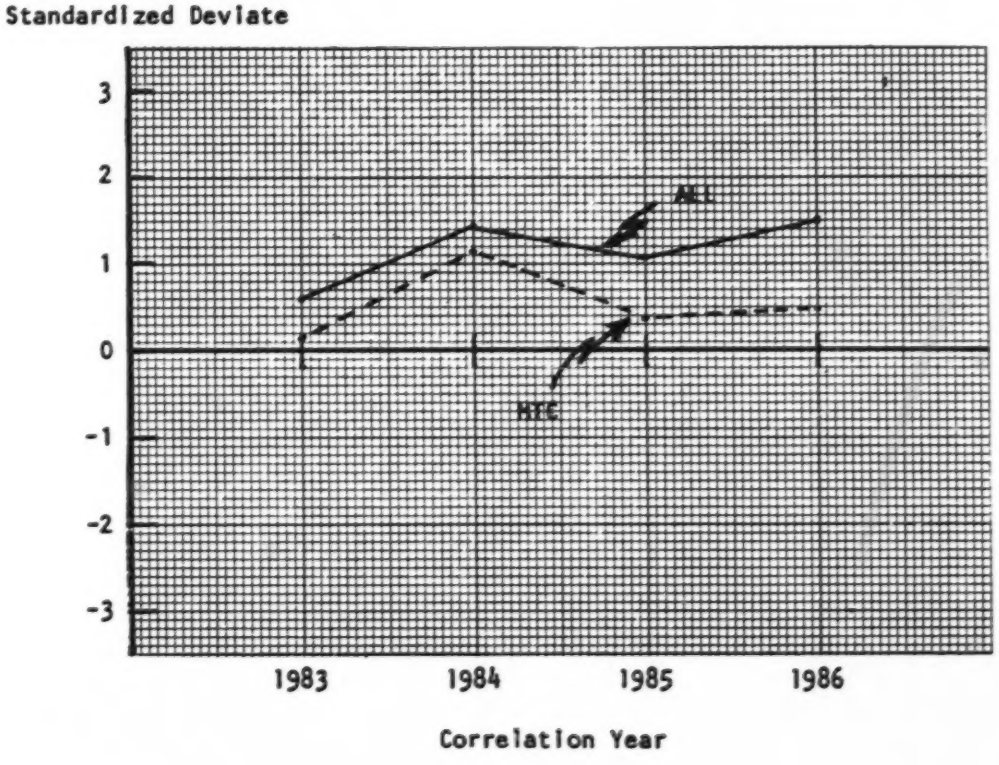


Figure 24: Marshall Flow, Thunder Bay

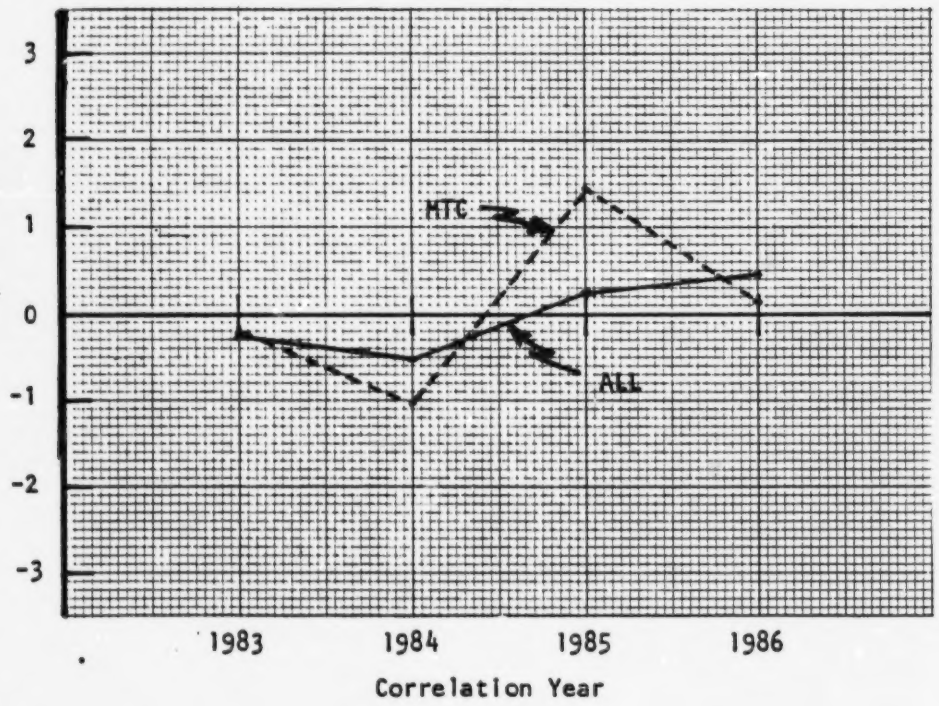


Figure 25: Marshall Flow, North Bay

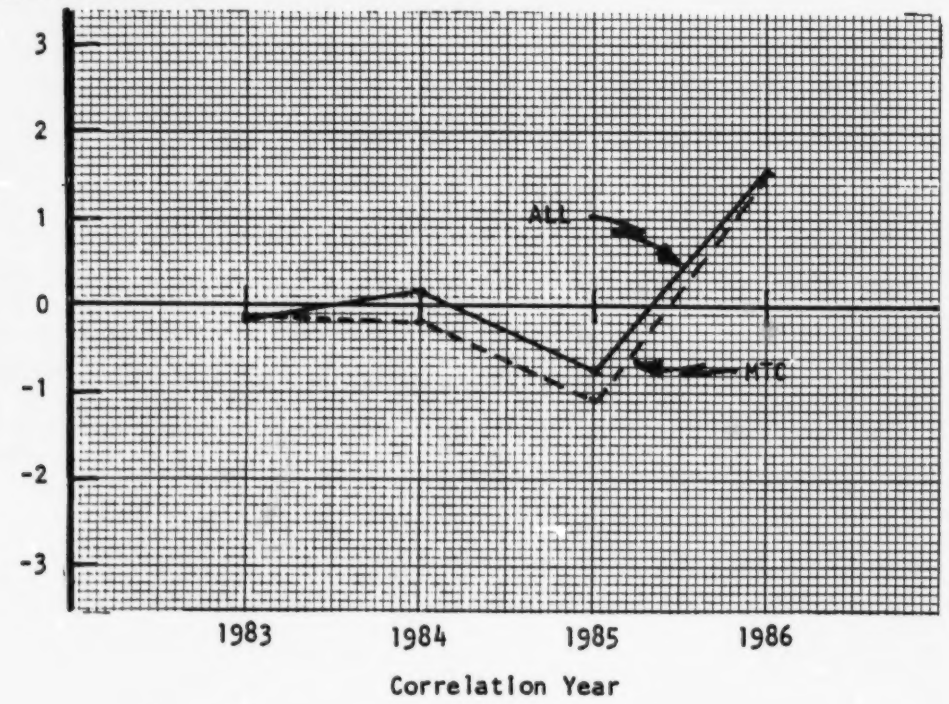


Figure 26: Marshall Flow, Eastern

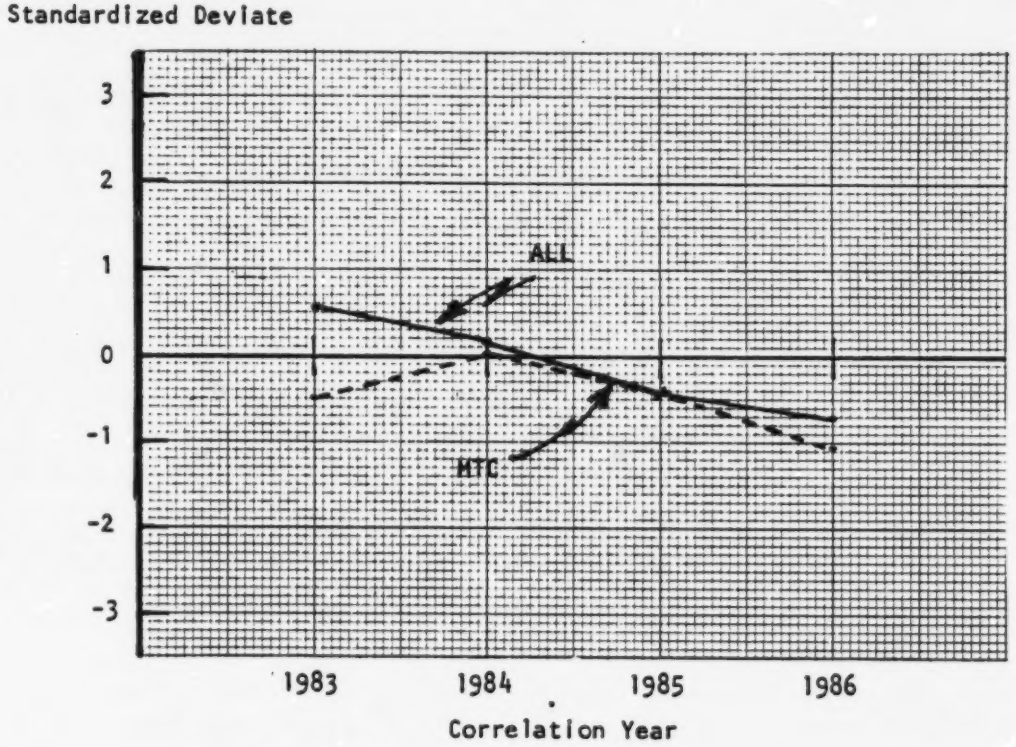
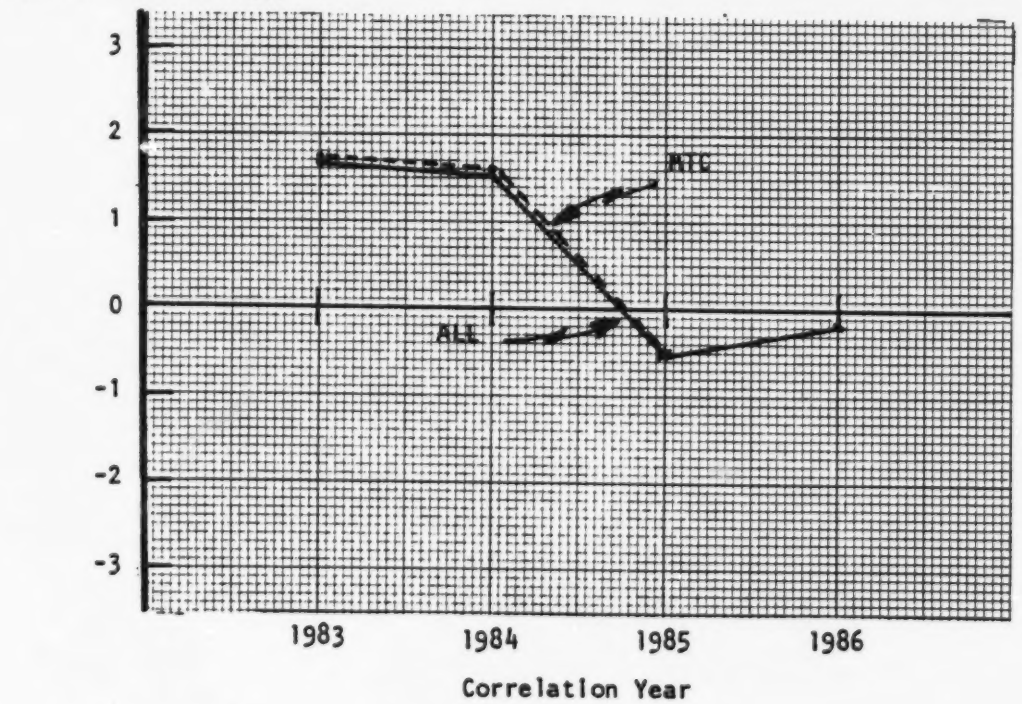
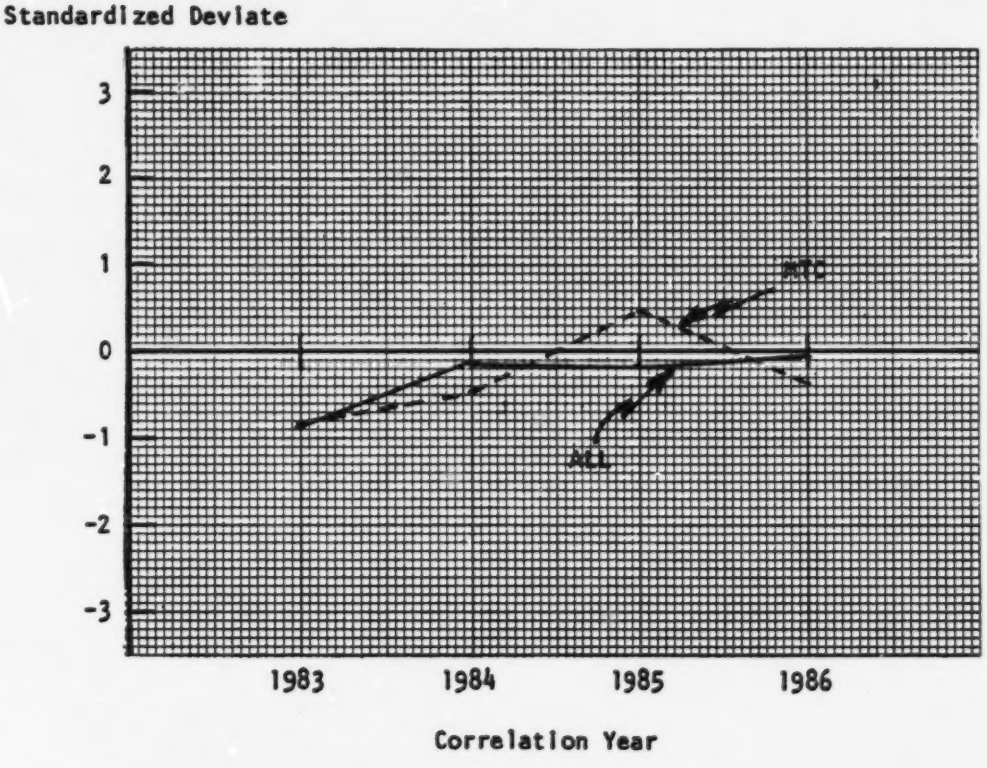


Figure 27: Marshall Flow, London



CTA CORRELATION DATA

Figure 28: Marshall Flow, Downsview (mix design)



APPENDIX I

In the CTA correlation data is reported by all participating laboratories and with the exception of data lying outside the acceptable limits (>3.0 standard deviations) all data points are included in the statistical analysis.

The CTA organization also certifies laboratories on the basis participation, completion of specified tests included in the correlation and the acceptability of the results obtained.

For the years 1984 and 1985 the total number of laboratories participating in these correlations were 34 and 39 respectively. Of these, 22 and 16 laboratories were certified by CTA. The statistical data for All CTA certified laboratories and for the MTC CTA certified laboratories are listed in TABLE I and II of this Appendix.

Differences in the arithmetic means between certified MTC and ALL laboratory groups are shown all with the differences on the basis of total correlation groups. These are averaged in TABLE II. Thus it can be seen that differences due to the certified vs total correlation groups is in the range of 0.002 to 0.004. It is therefore concluded that selection of data from either the total group or only the certified group of laboratories has better or no effect on the four year average difference of 0.025 between MTC and ALL CTA case.

APPENDIX I

TABLE I

COMPARISON OF BRD DATA FROM 1984 CTA TYPE A CERTIFIED MIX DESIGN LABORATORIES

Laboratory	Material #1		Material #2	
	ALL	MTC	ALL	MTC
01	2.401	2.401	2.421	2.421
02	2.417	2.417	2.431	2.431
04	2.424	2.424	2.440	2.440
05	2.412	2.412	2.439	2.439
06	2.410	2.410	2.419	2.419
07	2.420	2.420	2.413	2.413
11	2.337		2.358	
14	2.401		2.406	
15	2.460		2.465	
16	2.393		2.413	
17	2.374		2.395	
18	2.347		2.372	
23	2.335		2.344	
25	2.384		2.405	
26	2.373		2.386	
27	2.343		2.358	
29	2.342		2.355	
31	2.339		2.357	
32	2.390		2.377	
36	2.375		2.394	
37	2.381		2.388	
69	2.381		2.370	
n	22	6	22	6
$\bar{x}$	2.383	2.414	2.396	2.427
s	0.034	0.008	0.033	0.011
Difference(x)				
Certified	0.031		0.031	
ALL[1]	0.029		0.034	

[1] From TABLE XVII

APPENDIX I

TABLE II

COMPARISON OF BRD DATA FROM 1985 CTA TYPE A CERTIFIED MIX DESIGN LABORATORIES

Laboratory	Material #1		Material #2	
	ALL	MTC	ALL	MTC
04	2.414	2.414	2.410	2.410
05	2.408	2.408	2.401	2.401
06	2.408	2.408	2.401	2.401
07	2.417	2.417	2.408	2.408
19	2.401	2.401	2.397	2.397
20	2.415	2.415	2.401	2.401
11	2.395		2.378	
12	2.373		2.366	
14	2.400		2.391	
16	2.407		2.400	
17	2.409		2.391	
23	2.393		2.388	
24	2.391		2.365	
25	2.398		2.390	
26	2.405		2.377	
37	2.380		2.373	
n	16	6	16	6
$\bar{x}$	2.401	2.411	2.390	2.403
s	0.013	0.007	0.014	0.005
Difference(x)				
Certified	0.010		0.013	
ALL(1)	0.016		0.018	
Overall Difference				
Certified	0.021		0.022	
ALL(1)	0.025		0.026	

(1)From TABLE XVII